Proposed Upgrade to Masterton Wastewater Treatment Plant

Response to Further Information Request by the Greater Wellington Regional Council

Effluent Quality

1. Information Requested

What is the predicted increase in retention time and therefore expected improvement in effluent quality (in terms of predicted E.coli counts) as a result of the proposed maturation cell upgrade (p.86 of AEE)?

Reason:

This information helps determine the likely effectiveness of the proposed upgrade on effluent quality and therefore helps assess the effects of the pond discharge on the receiving waters.

RESPONSE

It should be noted that the overall pond volume is not being increased. With the construction of dividing bunds to form maturation cells within the secondary pond, there will be a slight reduction in the retention time due to the volume of the bunds. However, this is more than offset by the effectiveness of providing multiple ponds-in-series which reduce short circuiting and increase the actual retention time and disinfection effectiveness. The Marais formula, which predicts the reduction in E.coli, does not use the actual retention time. Instead, it applies a coefficient k to the nominal retention time, which varies from summer to winter. The k values used to predict effluent E.coli values were derived from existing data for Masterton, Blenheim and Christchurch ponds. The prediction method provides typical values; however, variations will occur due to climatic conditions.

The improvement in disinfection is expected to reduce the E.coli concentrations from a summer geometric mean of 485/100 mL currently, to a target of 200/100mL. Although there is likely to be some improvement in winter concentrations, they are not expected to be reduced significantly (refer Table 22 of AEE).

2. Information Requested

Please explain the rationale behind the geomean and percentile standards sought for effluent quality (Table 46 of AEE) and exactly how compliance is to be determined. Justification for the significant increase in some 90th percentile standards (compared with existing 95th percentile effluent quality) is also required.

Reason:

The proposed standards and compliance regime are not well explained or justified in the AEE or the supporting document by NIWA (2007). Nor are they intuitive. The 90th percentile standards sought for several parameters (suspended solids, DRP) are higher than the existing 95th percentile values from existing monitoring (which were the values used to predict in-river contaminant concentrations). The compliance regime suggests a 90th percentile standard but then allows a number of exceedances of the standard per year that is not intuitive with a 90th percentile. For example, suspended solids is (sic) *to be monitored monthly (12 results per* *year) but the proposed 90th percentile standard of 91 mg/L can be exceeded four times (75% compliance).*

RESPONSE

The proposed effluent quality compliance standards have been developed in accordance with the *New Zealand Municipal Wastewater Monitoring Guidelines*, 2002 Chapter 13 and Table 13.2 in particular (the relevant sections are attached as Appendix A). The method uses proportional compliance conditions as outlined in the Guidelines and uses a permissible number of exceedances of a percentile limit in a batch of samples, when also considering the risk of sampling errors. The compliance monitoring method is not intended to be "intuitive" in terms of a typical percentile standard, and the discussion in the Guidelines needs to be read to gain an understanding of the method.

The choice of a percentile for a given standard and use for compliance is arbitrary: a 90%ile standard has been chosen for most parameters while E.coli, metals TPH, PAHs, SVOCs, VOCs use the higher performance standard of 95%ile, as these parameters have higher ecological or health risks.

The compliance period is generally 1 year except for ammoniacal-nitrogen and E.coli which have seasonal compliance periods.

To clarify the requirements for suspended solids, the monitoring frequency proposed is actually fortnightly (not monthly as your letter indicates). Note that Table 46 in the AEE has some errors in the number of exceedances; the revised pages 179/180 are attached in Appendix B.

The Guidelines are regarded as good practice, and have been developed by a working group with representatives from district and regional councils, as well as from NIWA and the Ministry for the Environment.

Infiltration and Inflow

3. Information Requested

Please comment in further detail on your proposed programme of works, and your ability to invest further resources, to reduce infiltration and inflow (I & I) into the Masterton WWTP over the next 5-10 years.

Reason:

The Regional Freshwater Plan for the Wellington Region promotes a preference for land-based discharges of municipal wastewater where possible. The Masterton WTP's I & I rate is very high by national standards (average discharge in the order of 800 L/person/day compared with a typical average around 250 L/person/day) which, if reduced by targeting key areas of the system, could result in a significant reduction in the volume of effluent that is to be both treated and discharged, thereby increasing the potential for the discharge of a larger proportion of effluent on the proposed land disposal area. This is also a key issue for a number of submitters.

RESPONSE

The key benefit for the proposed wastewater upgrade is to remove the discharge from the river at times of low river flows when the river is most likely to be used for contact recreation, and to discharge to land. This is consistent with the policy preference set out in the Regional Freshwater Plan for municipal wastewater to be discharged to land where possible. Masterton District Council

(MDC) is seeking to increase the magnitude of this key benefit. An example of this is the recent purchase of the additional 107 ha of land for the purpose of effluent disposal which may allow an approximate doubling of the volume of effluent discharged to land with the result that there will be less frequent and less volume discharged to the River. Another example is the ongoing work that MDC has undertaken to reduce the amount of infiltration and inflow into the Masterton sewer network since the mid 1990's. These are two quite different projects, with different objectives, both of which involve a substantial investment by Masterton District Council.

The I/I reduction work undertaken by MDC since the mid-1990's includes:

- A number of flow monitoring studies to attempt to identify the worst performing parts of the network in terms of I/I,
- An extensive sewer grout sealing contract in the Bentley Street catchment,
- Grout sealing of sewers in the Lansdowne catchment,
- The repair of leaking manholes,
- CCTV covering approximately 30% of the 130km Masterton sewer network to further define poorly performing sewers in terms of I/I,
- Condition inspections of approximately 25% of the manholes in the Masterton sewer network to identify leaks,
- Private property I/I 'source detection' inspections of approximately 2,300 properties of the total number of 7,500 properties Masterton,
- Enforcement programmes to compel property owners found to have defects in their private laterals to repair them, and
- Substantial sewer maintenance work to arrest further deterioration.

The Cockburn Street sewer has been demonstrated to have particularly high I/I, and replacement of this sewer is currently being undertaken, including the replacement of approximately 2.4km total length of mains and lower sections of laterals, and 16 manholes.

This extensive work programme demonstrates the high priority MDC has placed on the reduction of I/I into the Masterton wastewater network.

What has been revealed during this work programme is that the I/I problem in the Masterton sewer network is widespread. Localised improvements have reduced I/I, but the progress has been incremental and relatively minor. Large scale I/I reduction cannot be achieved without undertaking large-scale repair or replacement work. However, the resolution of this problem is not a simple one. Masterton's most severe I/I is generally caused by groundwater. Consequently, localised repairs or replacement in one area tend to lead to elevated groundwater levels elsewhere, which then leads to groundwater re-entering the system through other defects located at a higher level.

The total replacement cost of the public part of the wastewater network is estimated to be in the order of $80m, with the private sections of laterals estimated to have a replacement value of an additional $35m. Much of the Masterton sewer network was constructed in the period from 1910 to 1916 and is therefore approaching 100 years old. Other sections constructed more recently in the mid 20th century are also proving to have high I/I. A total replacement of the sewer network is not affordable for the community so MDC’s approach is to maintain and improve the asset over time. Masterton’s long term goals for the urban wastewater infrastructure have been developed in collaboration with the community over an extended period of time, and form the basis for the operational and capital expenditure strategies set out in the Council’s 2006-2016 LTCCP.

The current plan is to expend approximately $400,000 per year on a combination of:

- Ongoing CCTV, manhole inspections, and private property I/I 'source detection' inspections to continue to seek to identify the areas with the worst I/I,
- Ongoing sewer and manhole replacement - high quality standards are being applied to this work to steadily reduce total system I/I as steadily increasing sewer lengths within the system

are made watertight,

- Ongoing assessment of the effectiveness of work by 'before and after repair/replacement' flow monitoring, and
- Ongoing programmes to compel property-owners to repair defects found in their private laterals.

MDC fully recognises that there is high I/I in the Masterton sewer network. It also recognises that the high wastewater flows that result from I/I make its objective of minimising wastewater discharge to the River more difficult. However, Masterton's situation in a low-lying area with high groundwater and gravel soils allows groundwater migration, meaning that a substantial reduction in I/I would be prohibitively expensive. Investigations undertaken for MDC estimated that, for substantial reductions in I/I to be achieved, the cost would be in the order of $5,000-$15,000 per m^3/day reduction in daily inflow to the plant. By way of comparison the cost of establishing an irrigation scheme is in the order of $1,000 – $4,000 per m^3/day of effluent irrigated. The costs of addressing that problem have to be prioritised against the costs of upgrading the Wastewater Treatment Plant (which is required by the interim resource consents obtained from the Regional Council in 2003), as well as against Council's other funding demands.

Taking these factors into account, Masterton District Council has optimised expenditure to best achieve the overall project objective of minimising wastewater discharge to the River. This strategy focuses the funding priority on upgrading the Plant to establish a treatment and disposal system that both immediately reduces discharges to the River (particularly over the crucial summer period) and which sets the basis for further improvements as funding permits and as opportunities occur.

In summary:

- Even without the additional land for effluent application, the discharge to the river and consequential effects will be much reduced as compared to the existing situation, and will be reduced to a level which is sustainable
- Nevertheless, the Council is committed to ongoing I & I work
- This will complement the upgrade
- The purchase of additional land for effluent irrigation is a more efficient way to further reduce discharge to the river than I & I reduction

Land Disposal Irrigation System

4. Information Requested

What is the soil type and irrigation application rates for the additional 20 ha of land referred to on p.88 of the AEE?

Reason:

There is 91 ha of land available but the soil type and irrigation application rate of only 71 (not 75 ha as stated) of land is described (54 ha free-draining and 17 ha clay-rich poorer draining soils). The soil type of the remaining 20 ha of land is critical to determining the appropriate effluent application rate.

RESPONSE

The 91 ha of land refers to the gross area of the site. The net irrigable area is estimated to be 75 ha after making allowance for buffer areas, the sludge handling area, the operations' building, inlet works area, access roads, stop banks and the 5 ha of native bush not irrigated.

Following a review of submissions, the 2ha area to the north of the site close to neighbouring properties in the Homebush Road area has been deleted from the border strip area. This area will have buffer planting and dripline effluent irrigation.

The approximate areas for the various soil types are provided in Table 20 of the AEE, and are given as 58ha of free draining soils and 17ha of clay rich soils. The 54 ha value stated in the fourth paragraph of section 6.4.1 in the AEE should read 58 ha. It is emphasised that the nominal 75ha of irrigable area could vary by +/- 5ha at the time of detailed design or during construction when the soils are exposed (refer also to item 5).

It should be noted that the lower bound area of 75 ha area was used in the water balance model to conservatively calculate the irrigation storage requirements (the lesser the irrigation area the greater the storage requirements). However, in order to determine the worst case effects of irrigation on the groundwater, the maximum area of 80 ha was used with the higher irrigation rates (these are shown in Table Q51 of item 5.

5. Information Requested

What are the predicted groundwater and nutrient concentrations for the newly proposed discharge regime (i.e., 100% border-strip irrigation on 91 ha of land with 10 m buffers)?

Reason:

Modelling by HortResearch and PDP was conducted on only 75 ha on the basis of drip irrigation at a lower application rate on the 17 ha of poor draining soils and 20 m buffers. The proposal is now to discharge all effluent onto 91 ha of land via border-strip irrigation with a buffer of only 10 m. Modelling needs to be re-run using these new 'conditions' to substantiate the statements made in the AEE that the revised discharge scenario will not significantly change the outputs modelled under the original discharge scenario.

RESPONSE

Refer to the above discussions regarding the net irrigable area versus the gross area. The irrigation and groundwater models were re-run for the whole of the 80 ha irrigated area (as an upper bound case) in border strip with 10m buffers around the site and no irrigation to the area of native bush. A further refinement following feedback from neighbours to the north of the site was that the 2 ha area of land to the north of the Makoura Stream would not be irrigated.

The current groundwater modelling is conservative because it does not allow for adsorption or transformation of nitrogen or phosphorus in the aquifer, nor adsorption of bacteria in the aquifer (only die-off), both of which will occur. However, in order to consider an upper bound case (referred to in question 6), the irrigation and groundwater models were re-run using the upper limit area of 80 ha and the highest expected irrigation and rainfall rates as shown in Table Q5.1 below[1]. Note that for the re-run of the groundwater model we have only presented the data for the upper bound case as groundwater concentrations from the irrigation are very low for both average and upper bound cases.

Table Q5.1: Soil Types and Proposed Average Seasonal Irrigation Rates

Soil Type	Area (ha)	Summer (mm/day)	Winter (mm/day)
Free draining	63	15	5
Clay rich	17	10	5

[1] 80ha was determined to be the upper limit of the irrigated area and accordingly likely to have the worst case effects on the groundwater (the actual area would be confirmed with the detailed design).

Total area	80		

In addition the groundwater model was run as a transient rather than a steady state model. Changes to make the grid spacing of the model larger and averaging the drainage data over monthly periods have now allowed a transient model to be successfully run. This change was to address the concern, raised in question 6, that the worst case was not being modelled. It is considered that monthly data rather than daily data, still provides variations due to seasonality given that significant damping of short-term fluctuations will occur within the aquifer.

Results of groundwater concentrations, flows and mass fluxes for the various boundaries along the Makoura Stream and the Ruamahanga River for the 'High Rate' case are provided in Table Q5.2 below. The output model for bacteria and nitrate (and to a lesser extent phosphorus) reflects the seasonal cycles of the input data with nitrate and bacteria concentrations lowest in summer and highest in winter.

As the combined effects on the river of pond leakage and irrigation groundwater discharge are expected to be the greatest during the summer when the river flow is lowest, it is most appropriate to calculate the mass flux for the summer period. Taking the lowest summer value is not reasonable, so the summer mean mass-flux was calculated, summer being defined as the period from November to April.

Table Q5.2: Groundwater Concentrations, Discharges and Mass Fluxes from Irrigation Adjacent to and into Makoura Stream and Ruamahanga River

Location	Groundwater Concentrations				Additional Discharge		Mass Flux			
	Nitrate-N (mg/L)	Bacteria (cfu/100ml)	Phosphorous (mg/L)		Short-term (m^3/day)	Long-term (m^3/day)	Nitrate-N (g/d)	Bacteria (cfu/d)	Phosphorous (g/d)	
			Short-Term	Long-Term					Short-Term	Long-Term P
Makoura Stream – Maximums										
Zone E	0.64	0.1082	0.0039	0.012	31.6	59.1	20	34,130	0.12	0.74
Zone F	0.83	0.1424	0.0039	0.021	41.7	56.5	35	59,370	0.16	1.19
Zone G	1.41	0.1597	0.0063	0.033	208	271	295	332,650	1.31	9.08
Zone H	0.25	0.0056	0.0005	0.001	1010	1207	254	56,500	0.52	1.12
Means & Totals	0.47	0.0374	0.0016	0.0076	1292	1594	604	482,650	2.1	12.1
Ruamahanga River – Summer Means										
Zone D	1.9	0.4257	0.0061	0.057	506	723	966	2,152,960	3.1	41
Zone C	0.8	0.1623	0.0027	0.057	652	829	545	1,058,400	1.7	47
Zone B	0.9	0.8127	0.0105	0.273	1082	1316	970	8,789,660	11.3	359
Zone A	0.9	5.8E-05	0.0088	0.172	231	342	201	130	2.0	59
Zone I	0.7	1.7E-09	0.0021	0.012	217	265	159	0	0.5	3
Means & Totals	1.1	0.4465	0.0069	0.146	2688	3475	2841	12,001,150	18.6	509

Note: *Rounding in calculations may cause small discrepancies*

A different approach was taken for the Makoura Stream. For the stream there are a small number of flow gaugings from March 2005 which are reasonably representative of summer flows, but may not be representative of the lowest flows. To introduce an element of conservatism, the maximum mass flow was determined over the 8 year record. The calculation of long-term phosphorus mass-flux followed a similar approach, but used the results from the last few years of the 28 year output file.

Comparing the results to the original modelling, the results in Table Q5.2 show that the increase in flow to the stream and river are little different to the original modelling for the 'High Rate' option (Options 3). For the river, using summer means from the transient model results in a small reduction in groundwater discharge compared with the steady state model, despite the greater irrigation area. For the stream the increase in flow is 50% greater than previously (0.015 m^3/s rather than 0.01m^3/s) but this difference is small compared with the natural flow.

Groundwater concentrations at the point of discharge to the stream and river given for the original modelling are given in Table Q5.3 for comparison purposes (extracted from Table 8 PDP, 2006). An exact comparison cannot be made because slightly different representative points were chosen in the model. In general terms, nitrate and bacteria concentrations adjacent to the Makoura Stream are smaller but of the same order of magnitude. A similar situation exists for phosphorus short-term, although the new results are slightly higher than the original. A comparison with long-term phosphorus cannot be made as long-term phosphorus was not calculated for the high rate scenario in the original modelling.

Table Q5.3: Original Modelled Concentrations Along River and Stream Boundaries (from PDP, 2006)

Waterway	Adjacent Irrigated Plot No	E.Coli (cfu/100 mL)		Nitrate-N (mg/L)		Phosphorus (mg/L)		
		Opt 3	Opt 6	Opt 3	Opt 6	Opt 3 (short term)	Opt 6 (short term)	Opt 6 (long term)
Makoura	1	1	1	0.5	0.5	0.001	0.001	0.002
Makoura	2	1	1	0.5	0.5	0.005	0.005	0.028
Makoura	3	0.5	0.5	0.5	0.5	0.0025	0.001	0.002
Makoura	4	3	1	1	0.8	0.0075	0.005	0.058
Makoura	5	2	0.5	0.5	0.3	0.0025	0.001	0.007
Makoura	11	0.05	0.01	0.01	0.01	0.001	0.001	0.001
Ruamahanga	8	10	5	2	1	0.01	0.005	0.049
Ruamahanga	9 & 10	10	5	0.5	0.3	0.01	0.005	0.129
Ruamahanga	Ponds	0.0001	0.0001	1	1	0.02	0.01	0.162

Concentrations adjacent to the river are similar to the original modelling for nitrate and short-term phosphorus, and two or more orders of magnitude lower for bacteria. This is due to the input data cycling through one or two order of magnitude from summer to winter for bacteria, whereas nitrate typically varies two fold. Also, bacteria has an additional first order decay parameter (to model die-off) whereas nitrate does not (it is assumed to be conservative).

The concentration increases in the stream and river are small compared with background concentrations and would likely be lost in the background fluctuations. The background concentrations for various locations are given in Table Q5.4 (taken from Table 10 in PDP, 2006).

Table Q5.4: Background Concentrations in Ground and Surface Water 2003/05 [1]

Location	E. Coli (cfu/100 ml)		Nitrate-N (mg/L)		DRP (mg/L)	
	Mean	Median	Mean	Median	Mean	Median
Groundwater HB5, 6 and 9	1.2	1	1.3	1.3	0.02	0.014
Makoura Stream at Mak1	1040	420	3.5	3.7	0.02	0.02
Ruamahanga River at Rua1	450	60	0.6	0.7	0.01	0.01
Notes:	1. From consent monitoring reports					

6. Information Requested

What are the predicted groundwater and nutrient concentrations for the newly proposed discharge regime in 5) above when 95th percentile effluent concentrations and the effects of contaminated pond leakage on groundwater are considered?

Reason:

The modelling used average effluent concentrations and it would be useful to see the worst-possible case contaminant 'pulses' moving through soil and groundwater to the Ruamahanga River and Makoura Stream. The modelling also did not take into account contaminants from pond leakage. Pond leakage and infiltration from the irrigation area should be considered together.

RESPONSE

With respect to the use of 95th percentile values for effluent quality in the groundwater model, we consider that those values are not appropriate given the buffering effects of additional pond storage, soil adsorption capacity and the smoothing effect of groundwater travelling from the irrigated area to the receiving waters. As discussed in question 5, the model was developed into to allow the analysis of transients using monthly data in order to determine the seasonal variations in groundwater concentrations. The modelling data presented in question 5 is for the 'High Rate' case and thus is the conservative assessment of the groundwater flows and concentrations. The current groundwater modelling is also conservative because it does not allow for adsorption or transformation of nitrogen or phosphorus in the aquifer, nor adsorption of bacteria in the aquifer (only die-off), both of which will occur.

With respect to the pond leakage, the groundwater model did not include pond leakage effects as this would not be practical, considering the complexity of the varying leakage rates that are likely to be occurring over the pond area.

We consider that pond leakage is only relevant when evaluating the effects on the receiving environment. The irrigation modelling gives the increment from the irrigation over and above what is currently occurring from the pond leakage (which has been measured in the river). The outputs from the irrigation model have been simply added to the pond leakage to give the combined effects. Attempting to model the pond leakage will not provide a better answer than this. Question 24 also required comment and supporting analysis of the cumulative effects of all three discharges (pond seepage, land disposal and direct river discharge) on the Ruamahanga River. We have provided the results of this analysis under Question 24.

7. Information Requested

Why is border-strip irrigation the preferred disposal method? What alternative methods were considered?

Reason:

Border-strip irrigation can commonly result in over-application of water and nutrient leaching. Section 10 of the AEE does not discuss alternative methods of disposal (e.g., spray or drip irrigation). A number of submitters have raised concerns about the method of irrigation chosen.

RESPONSE

The choice of border strip instead of spray irrigation was made after consideration of a range of factors as outlined below.

While spray irrigation has advantages in some situations, border strip irrigation was the preferred method for this effluent irrigation scheme.

When spray irrigation of effluent is proposed, usually there are many submissions which raise concerns about spray drift and aerosols causing effects on neighbours' health (in this regard, some submissions on the Masterton consents have mentioned the effects of "spray drift" even though spray irrigation is not proposed). Typically, to mitigate such concerns, applicants for spray irrigation schemes typically propose additional mitigation measures such as; UV lamp disinfection, larger separation distances and/or to stop spraying when the wind direction could carry aerosols onto residential properties, roads or recreational areas. If the applicant does not offer such mitigation measures, on the basis of other decisions elsewhere in New Zealand, the consent authority would be likely to impose such conditions. It should be noted that a UV system for pond effluent would have an additional capital cost of $1.7 million and operating costs for power and lamp replacement of $200,000 per year.

While technical justifications can demonstrate that the risk to public health might be minor, the perceived effect of effluent sprays (which are very visible) has been recognised elsewhere as a valid effect. The public is familiar with how far the spray will travel from a lawn sprinkler or a farm irrigator, under strong winds, and members of the public do not accept the difference in potential effects between low vs. medium vs. high pressure sprays.

Submission 30 refers to "the lay of the land with humps, hollows and changing gradients" and also to "areas of heavy soil in hollows". With a spray irrigation scheme, it is not usual practice to re-grade the site to uniform slopes, because the costs for spray irrigators and distribution pipework are already significant. For cleanwater irrigation, the consequences of runoff to hollows and ponding are minor, and, if needed, the application rate can be readily reduced (as has been required for the spray irrigation system operated by the previous landowner). However, for effluent irrigation, runoff to hollows and ponding would lead to odour emission, as the ponded effluent decayed. This effect would be exacerbated by a more rapid build-up of algae solids in the hollows, which would increase the ponding volume and duration. For a border strip system, algae solids are well distributed down the length of the strips and do not clog the topsoil due to the alternating wetting and drying cycles and biological activity in the topsoil.

Accordingly, for these reasons, and where the topography is suitable (as is the case at Masterton), it is preferable where effluent irrigation is proposed to grade the land to uniform slopes so that ponding does not occur. The re-grading also allows runoff to be collected and directed to enhanced infiltration areas within the wipe-off drains, with surplus first-flush volumes pumped to the ponds. Such a management system would not be possible for a spray application scheme where the land is not re-graded.

A key advantage of border strip irrigation is that effluent can move down the strips and percolate into the soil at the localised rate, as dictated by topsoil moisture demand and underlying drainage characteristics; this process is inherently self-correcting. Hence, it is not possible to apply more effluent than the soil's hydraulic capacity to accept, as is possible with other spray systems. Thus, hydraulic loading rates can be maximised in keeping with the key objective for this scheme which

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seeks to divert effluent away from the river, particularly at low river flows. Effects on groundwater in terms of nutrient breakthrough will be monitored and application rates can be adjusted for specific areas on the basis of operating experience.

Border strip systems have been criticised because of the difficulties in automating the distribution system and measuring the flows in open head race channels. In addition, gates to individual border strips can often leak creating permanently wet areas with anaerobic soils. To avoid these problems, a piped distribution system will be installed with bubble-up valves to individual strips which are leak-tight when shut, and actuated valves to groups of strips which will allow the system to be largely automated, with overview inspections by an operator.

Effluent application to land systems elsewhere in New Zealand have been designed to the site specific constraints of topography and soil infiltration rates. Spray systems have been used for steeper slopes (Rotorua, Levin, Whangamata and Whitianga) or where the soils are very free draining (Taupo on pumice soils). Border strips have been used successfully for up to 40 years, for alluvial plain locations similar to Masterton: at Templeton, Burnham, Waimate and Leeston (refer to the Leeston poster attached as Appendix C, which was displayed at the NZWWA Conference in 2006, and to the article in the *Local Government* magazine, attached as Appendix D).

A very large system has operated at Werribee (southwest of Melbourne) for over 100 years (refer to the paper in Appendix E, and the aerial photographs in Appendix F). This system handles a flow from 1.6 million people using some 4,200 ha of the 11,000 ha total area, and uses the flood irrigation method with check borders (similar to border strip). Effluent percolates slowly through the permeable soil and is collected by a network of deep open drains. The typical soil profile is a red-brown silty clay loam, with 35 % clay, 45 % silt and 20% sand. Thus, in comparison, the Werribee soil profile is less permeable than at Masterton where the underlying gravel strata and proximity to the river allows for adequate sub-drainage.

Buried drip-lines would mitigate the health concerns, but application rates would be restricted and the topsoil uptake of moisture and nutrients would be reduced.

In addition, the long-term performance of drip-lines handling pond effluent is uncertain. Clogging of the sub-surface soils close to the emitters would occur with higher application rates. Removal of algae prior to drip-lines would be prohibitively expensive. It is justified to install driplines in the perimeter buffer planted areas, because the “visible effluent” effect is avoided. Also, it would not be a major cost if the driplines had to be replaced at a future date, if clogging of the subsoil occurred.

Thus, in summary, the border strip method has similar costs to the spray and buried drip-line options but has the key advantage for the Masterton site of the surface undulations being removed during the re-grading of the site. It will also avoid the common community concerns associated with spray irrigation. The border-strip irrigation method for oxidation pond effluent disposal has the longest successful operational history, both in New Zealand and Australia, even in soils with less favourable filtration characteristics than those at the Homebush site.

8. Information Requested

Please explain the level of earthworks required to establish the border-strip irrigation system, and how any earthworks may affect any changes in soil properties and characteristics.

Reason:

The feasibility of border-strip irrigation has been questioned by a number of submitters.

RESPONSE

Typically, the earthworks for the formation of border strips involve grading the near-surface soils to provide a shallow fall of between 1 in 300 to 1 in 500 gradient. Border strips would be a minimum width of 12m and up to 50 m and be separated with a low (300mm) bund. Some modification of the land surface is therefore necessary.

To achieve effective treatment of the effluent by filtration through the topsoil and subsoils, the earthmoving will be managed more intensively than is the case for typical on-farm situations, so that local areas with extremes in permeability will be modified to be close to the average values for the site. This will be achieved by the following measures:

a) Topsoil will be stripped and temporarily stored in longitudinal piles to allow the sub-base to be graded to the required fall. Uniform depths of topsoil will be placed on the re-graded sub-base, the local depth being dependent on the available topsoil in the locality. Since the topsoil provides a significant portion of the water holding capacity, border strips will have a more uniform water absorption rate compared to a spray system on "natural" alluvial ground that would have variable topsoil depths.

b) Where gravels protrude to the surface, these will be removed and reused for the construction of pond bunding. This source of gravel will be lower cost than alternative sources and the extracted gravel volume from the irrigated area will be maximised. The gravel areas will be backfilled with silty sand as a sub-base and compacted to match the density of the surrounding soils so as not to provide a preferential flow path and the topsoil will be reinstated.

c) Localised areas of known existing ponding will be investigated during construction and the drainage improved with sand-filled slit drains if needed (most likely to be required where there are soils with significant depths of underlying silty clay).

d) The earthworks will be carried out in the summer season to avoid excessive compaction of the soils. Full-time construction monitoring of the earthworks will be implemented for good quality control.

e) Construction equipment will be fitted with laser-guided features for precise level control.

f) By handling the topsoil separately, there will be minimal changes to the near surface soil characteristics, thus allowing pasture to be re-established quickly. The proposed changes to subsoils will be to improve the filtration characteristics.

9. Information Requested

Please explain how at least 97% of DRP will be removed/retained in the soil (p.138 of AEE) if site investigations revealed very low phosphorus retention rates (8-19% on p.93 of AEE).

Reason:

These statements appear contradictory – low phosphorus retention would suggest a high probability of leaching to groundwater.

RESPONSE

Modelling was carried out to assess the environmental fate of the surface-applied phosphorus. The results were reported in the HortResearch (2007) report which forms part of the AEE. The total phosphorus content of treated effluent from the oxidation ponds is expected to be, on average, 3.2 mg L-1. Most of this content will be in the form of dissolved reactive phosphorus (DRP) which adsorbs partially to the soil's clay and mineral particles, and is also easily taken up by plants.

The proposed irrigation scheme would add between 28 and 63 kg P/ha each year to the pasture sites. Some 20-35 kg/ha of this would be assimilated by pasture that is subsequently harvested and removed from the site under the cut-and-carry operation. Irrigation of treated effluent adds more phosphorus to the soil than can be utilized by the pasture, so there is opportunity for leaching to occur. However, the remaining DRP is largely retained, or filtered, by the soil profile. The degree of renovation will depend on the interaction between soil processes and water movement.

For the purpose of modelling, P partitioning in the soil was described using a Langmuir adsorption-isotherm that relates the equilibrium solution concentration [C, mg/L] to the amount of P adsorbed onto the soil matrix [q, mg/kg]. Figure Q9.1 below presents isotherm data from the Bw horizon (clay loam at 50 cm) where the P retention is 19%. The maximum sorption capacity of these clay rich layers is typically between 410-615 mg/kg.

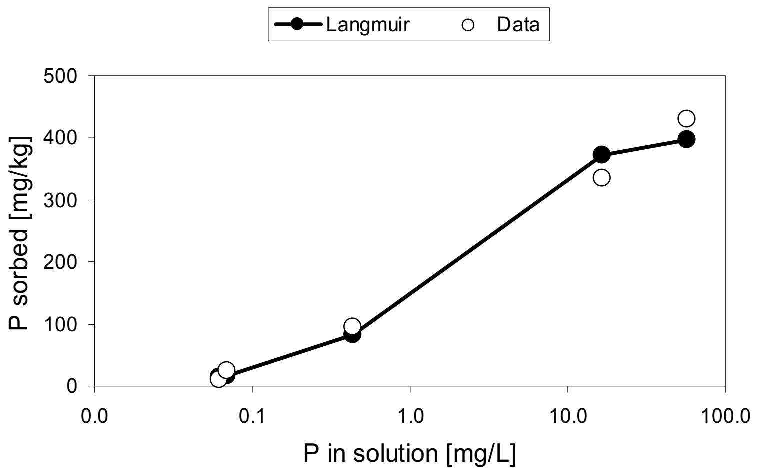


Figure Q9.1: Langmuir isotherm for P retention in soil from the Bw horizon (50-53 cm deep) at the Homebush site (source: HortResearch, 2007; Figure B2)

Following 28 years of historic application of phosphorous to the existing pasture, a large fraction (~60-80%) of the applied P still resides in the top 1.0 m of the soil profile (Figure Q9.2). While the soil concentration slowly increases over time, it is still a factor of 2-6 times lower than the maximum concentration at saturation (Figure Q9.2 cf. asymptote of Figure Q9.1). On site 3, the solution concentration in the drainage water at 1.0 m depth is < 0.01 mg L-1, representing a 99.7% reduction in the concentration of DRP. The corresponding concentration could slowly rise to 0.2 mg L-1 on the most free-draining soils receiving the highest nutrient loadings (for example, site 7). On those sites, there will be a 94% reduction in the concentration of DRP. It should be noted that additional dilution in the groundwater, combined with strong adsorption by the deeper clay-rich layers, means the off-site impacts on surrounding ground water are likely to be negligible.

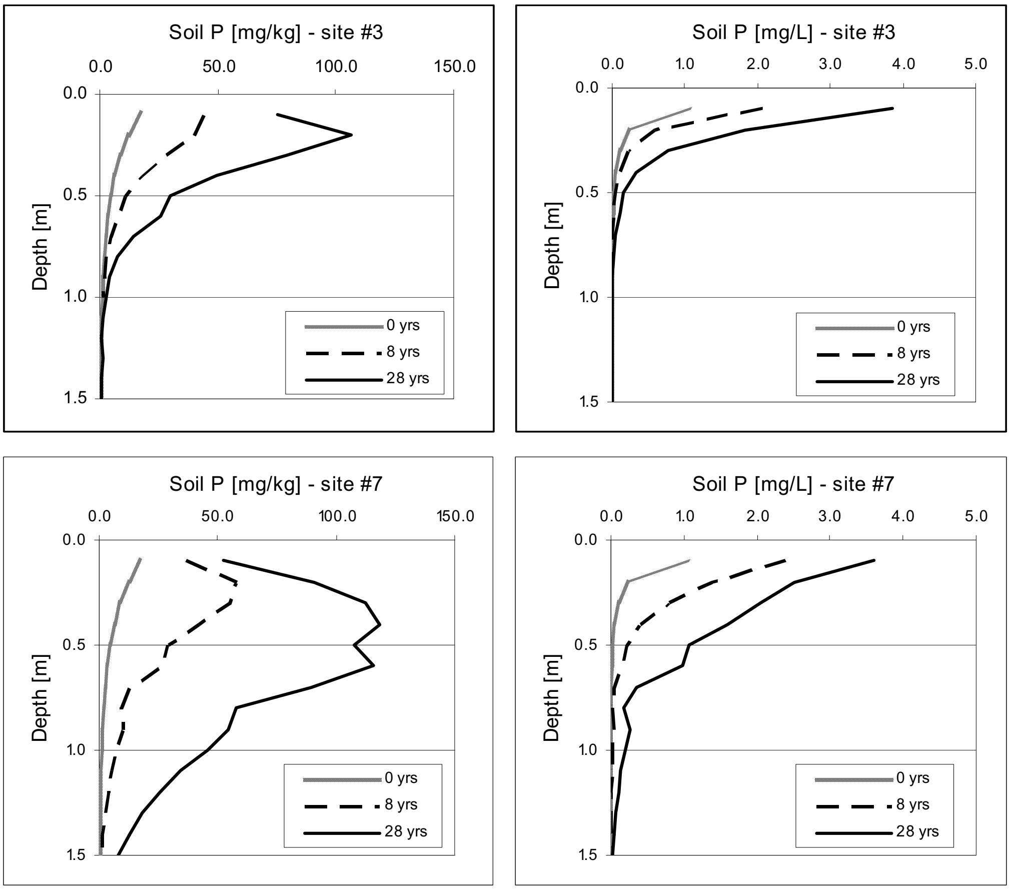


Figure Q9.2: The concentration of phosphorus attached to soil (left panel) and the corresponding solution concentration (right panel) in water that that drains under disposal site 7 at the Homebush site. The annual loading equates to 61 kg ha-1 of phosphorus, applied at an influent concentration of 2.5 mg L-1 (source: HortResearch, 2007; Figure 5)

References:

Masterton Wastewater Upgrade – Groundwater Modelling, Pattle Delamore Partners, December 2006

HortResearch 2007. Green S. *Modelling the Environmental Effects of Wastewater Disposal at the Masterton Land-Based Sewage Effluent Disposal Scheme* (HortResearch Client Report No. 21183).

10. Information Requested

How will land-based irrigation be managed in rainfall (e.g., what rainfall will trigger cessation of discharge)?

Reason:

Heavy and/or unexpected rainfall during land irrigation may result in saturation of soils and increased surface runoff or leaching to groundwater.

RESPONSE

Generally, the irrigation depths in the summer will be controlled to provide an average application of effluent plus rainfall of 10mm/day in the summer and 5mm/day in the winter for the free draining soils. Rainfall and soil moisture will be monitored daily and the operator will make a decision on the actual depth of effluent to be applied. An automatic rain gauge would be used to stop the irrigation pumps in the event of significant rainfall that would result in an effluent/rainfall depth greater than an average application of 10mm/day. It should be noted that only some areas will be irrigated on any particular day. Thus any runoff from recently irrigated areas due to unexpected heavy rainfall will be diluted by runoff from areas that have not received effluent for about one week.

Some experience will be required to determine the depth of application to allow the effluent to just reach the end of the border. In the event that effluent or rainfall runoff reaches the end of the border strip, it will be discharged to the wipe-off drain for collection. The proposal (explained in the AEE) is to discharge effluent collected in the wipe-off drain back to the ponds, with excess rainfall discharged to the Makoura Stream. The drains will be enhanced by installing areas of sandy gravels to increase infiltration of the effluent/stormwater to reduce runoff pumped back to the ponds or stormwater discharges to the Makoura Stream.

11. Information Requested

Please comment on the potential risk to the border-dyke irrigation field intended to be situated within the flood hazard zone on the river side of the stopbank.

Reason:

This area will be subject to flood events, therefore further consideration of managing flooding risks in this area should be completed: i.e., what works will be necessary and undertaken post flooding events to ensure that the border dyke irrigation fields can still be used.

RESPONSE

The riverside area is subject to relatively infrequent flood events of a five year return period. During flood events there will be some deposition of silt on the berm area, but the effect of which will depend on the severity of the event. Where significant silt deposits have occurred, these may need rotary hoeing and re-sowing of the grass. It was stated in section 6.4.8 of the AEE that pastures would be re-sown every four to six years. Thus, on average, the re-sowing of the riverside area would not be more frequent than the land to west of the stopbank. Flood events are not expected to cause any damage to the border strip earthworks.

Flood flows over the berm area border strips would have no discernable effects on water quality. Irrigation to these areas would be stopped well before the flood flows cover the berm, providing effluent time to percolate through the soil and not be removed during floods.

12. Information Requested

Further consideration should be given to potential monitoring of domestic bores adjacent to the land irrigation area.

Reason:

A number of submitters are concerned about groundwater contamination.

RESPONSE

The modelling shows effects on these bores to be highly unlikely for the current scheme. Monitoring would be a relatively inexpensive means of reassurance for both the current proposal and for an enlarged scheme using the additional land recently acquired by the District Council.

Pond Seepage/Leakage

13. Information Requested

Given that pond seepage and infiltration rates are closely correlated with flows in the Ruamahanga River, please comment on the validity of the pond leakage estimates provided and, if appropriate, submit a revised worst-case daily leakage volume.

Reason:

Intuitively it would be expected that pond leakage would be greatest in summer low flows but, as also pointed out by a submitter, several attempts to estimate pond leakage were undertaken in the winter months and PDP's modelling was undertaken over a limited period in autumn with no attempt made to correlate pond flows to river flows. PDP's report also appears to focus on "average" leakage conditions.

RESPONSE

Pond leakage is affected by the head difference, so leakage will be greater when the ponds are high and/or river is low, from basic fluid mechanics considerations. However, when the average daily and weekly river flows at Wardell's were plotted against the calculated leakage flows (see Figure Q13.1 next page), there is not an obvious pattern, despite a significant amount of effort that was made to correlate pond river flows and leakage flows.

The early leakage rates in February and March do not correlate well with the flow (m^3/s) averaged over a week or daily average flows. This is a period of low flow, typically around 3 to 10 m^3/s. For the later period of monitoring prior to pond raising, river flows are much more variable and again do not correlate well with leakage rates. There may, however, be a slightly smaller leakage rate through April and the first three weeks of May that may reflect the higher average river flow (and river levels), which range from around 10 m^3/s up to about 55 m^3/s, when averaged over the week.

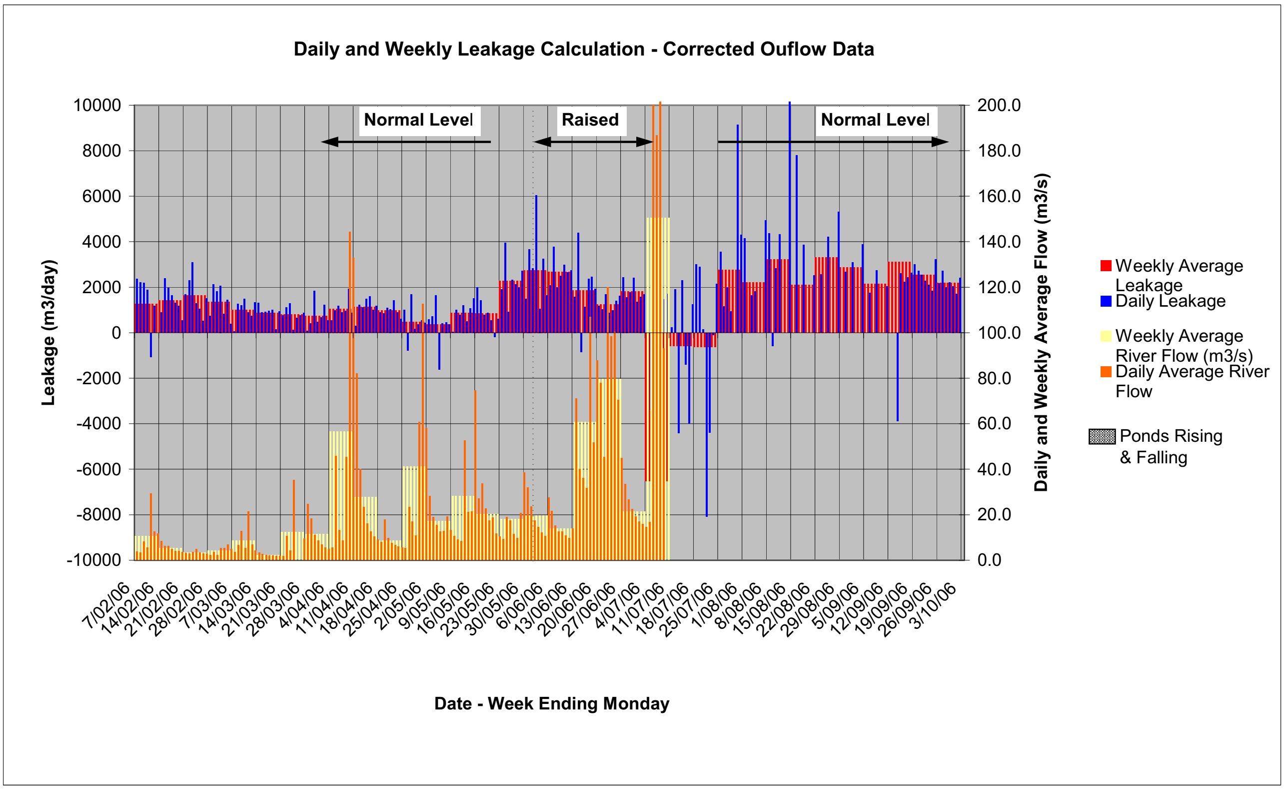
The lack of correlation is probably a function of the errors inherent in the calculation of the leakage (see *Wastewater Pond Leakage Estimate*, Pattle Delamore Partners, 2007). Essentially, the inherent accuracy limitations of the flow measurement devices results in uncertainties obscure the more subtle changes in leakage induced by the head changes due to changes in river levels. However, the general picture suggests that there is not a large change in river level between a flow of a few m^3/s and several tens of m^3/s (of the order of 0.5m), and that the early phase of the leakage experiment is a reasonable representation of leakage for low to moderate river flows: i.e., around 800 m^3/s ± 900 m^3/s, as per the report.

This is to be expected. River levels for low to moderate river flows during the trial are of the order of 0.5m.

Given the head difference between the pond and river of between about 3 m opposite Pond 1 and 5m or more opposite Pond 3/4, a difference of a 0.5m of head will not induce much change in leakage, assuming a linear relationship (as per Darcy).

In conclusion, submitting a revised leakage estimate is not appropriate because the estimate is considered to be valid, with the estimate range already sufficiently generous to cover any variation in small river level changes.

Figure Q13.1: Daily and Weekly Leakage Compared with River Flows



With respect to the comment about how average leakage was calculated, this method is unavoidable in the circumstances. Even if very much more sophisticated pond level monitoring had been undertaken (for example, installing large diameter stilling wells with automatic water level recorders at, say, four locations in each pond (at great expense)), there would still have been a need for averaging to deal with the inevitable fluctuations in apparent pond levels caused by waves, wind-setup and measurement error, and still uncertainty with respect to the other measurements making up the leakage calculation. It is contended that the calculation methodology used was reasonable in the circumstances and shows the difficulty of trying to achieve a precise measurement with the tools at our disposal. It is simply impossible to calculate a precise instantaneous leakage rate where daily leakage rates were too variable to be useful, as in this case.

14. Information Requested

Please provide an estimate of the expected leakage from the ponds after desludging.

Reason:

There is limited information on the quantity of leakage following the proposed desludging and the potential effects of pond leakage following desludging.

RESPONSE

The precise leakage mechanism is not known exactly, but it will be a combination of leakage out of the base with leakage out the embankments towards the river, with perhaps some discrete leakage points through higher permeability zones associated with the old meander channels. There will be variable blinding (filling of small spaces) of the underlying gravels by the sludge.

When the ponds are desludged, at least 100mm of sludge will remain in the ponds to provide a sealing layer. We would expect there to be a substantial blinding effect from this remaining layer and also as the sludge settles into the interstices (gaps) within the gravels. Field tests have showed that natural sealing from sludge in oxidation ponds with more permeable soils, reduced the leakage by a factor of tens to several hundred times, and resulted in a permeability of 10^{-8}m/s (USEPA 1983). Consequently, only a minimal increase in leakage is expected and the leakage rate will revert to existing values with a period of months as further sludge forms.

Pond 1 will be desludged at the time of the upgrade. However, Pond 2, having a lesser sludge depth and greater cover of pond liquid over the sludge, will not need desludging until around the year 2016.

15. Information Requested

Please expand on the methodology used on page 91 of the AEE where it has been determined that flows after 2 hours are considered to be stormwater.

Reason:

There is no reference to how this 2 hour period was established and reasons why excess run-off can be classified as stormwater after this period.

RESPONSE

The 2-hour period is the “time of concentration” when the flow from the extremities of the catchment reaches the pump station. At this time, the peak flow that occurs will be predominantly rainfall runoff, and contain only a very dilute concentration of treated effluent. On most occasions, treated effluent will not have been applied to land when heavy rainfall is predicted. Therefore, it is expected that runoff after two hours will have low concentration of contaminants.

An automatic rain gauge would be used to stop the irrigation pumps in the event of significant rainfall that would result in an effluent/rainfall depth greater than an average application of 10mm/day

So that the runoff flow reaching the pump station is minimised (and hence the volumes discharged to the Makoura Stream), it is proposed to enhance infiltration from the wipe-off drains to groundwater (as discussed in our response to Question 10).

Stormwater runoff will be discharged to the Makoura Stream only when the duration of rainfall exceeds 2 hours. After rainfall of this duration, the contaminants are removed from the surface and only 'clean' stormwater is discharged to the Makoura Stream.

River Discharge

16. Information Requested

What effects (water quality, habitat, etc.) are the discharges (direct and indirect) expected to have on the various fish species that inhabit or use the Ruamahanga River system both in the vicinity of the discharge and further downstream?

Reason:

The Ruamahanga River is an important waterbody for both native and introduced fish yet the information presented in the AEE on effects on fish is very limited.

RESPONSE

The information presented in the AEE on the effects of the proposed upgrade are predicated on the fact that the existing WWTP discharge has minimal effects on native or introduced fish. Because the proposed upgrade will remove direct discharge to the Ruamahanga during summer low flow conditions (when fish could be expected to be most affected), it was reasoned that the minimal effects noted with the existing discharge would be even further reduced.

The information presented in the AEE in regard to this matter is summarised below. In addition, some further comment is also made, drawing on some additional publications by Greater Wellington and Massey University.

Fishery information presented in the AEE

The AEE notes (at p.62) that there are a diverse range of fish species present in the Ruamahanga River, including native and exotic species (brown trout), as well as some exotic pest species such as perch and tench. Diversity is greatest in the Upper Ruamahanga, but Greater Wellington's own studies have shown that low flows and associated elevated water temperatures are the main factor restricting distribution of fish species in the middle to lower Ruamahanga River (supporting data was presented in the Appendix to the AEE).

Fish species known to present in the Ruamahanga River catchment were presented in Table A1.4, sorted by the maximum distance each species has been found from the mouth of the River. Distribution maps (Figures A1.5 –A1.7)[2] show that the diadromous torrent fish koaro and common bully are found in the upper Ruamahanga (and tributaries such as the Waingawa) and close to the mouth, but not in the middle to lower-middle reaches which are known to be impacted by low summer flows and high water temperatures. This shows that these species are able to pass through the main stem of Ruamahanga (including those sections most impacted by the existing discharge) for both upstream and downstream migrations. A similar distribution pattern was presented for brown trout (Figure A1.8), again suggesting that they avoid the lower-middle reaches in preference to areas above the Waingawa confluence, which have better habitat (through riverbank vegetation cover and cooler water temperatures).

[2] Note these distribution maps constructed from records retrieved from the NZFFD December 2005, superseded similar maps prepared by Cawthron Institute for Greater Wellington in 2001.

Additional information presented in the AEE of relevance to fish distribution

It could be argued that the dearth of fish species present in the lower-middle Ruamahanga main stem is indicative of the presence of a pollutant or pollutants. However, the data presented on invertebrate populations and densities (at p.61 of AEE) do not support this argument. High populations (and proportion of total invertebrate populations) of EPT species (indicative of good water quality) are present at Wardell's Bridge, within the mixing zone of the current discharge. In particular, the presence of high numbers of Deleatidium is significant because this species is very sensitive to toxic contaminants such as ammonia[3]. Thus, the high populations of Deleatidium is good evidence that water quality immediately downstream of the existing discharge would not have a significant effect on either native or exotic fish populations. This supports the hypothesis that habitat conditions, low flows and high water temperatures are the most likely cause of restricted fish distribution in the middle-lower Ruamahanga main stem.

Additional information not presented in the AEE

Bowie and Henderson (2002) studied the distribution of Short-Jawed kokopu (Galaxias postvectis) at 50 sites in the Mangatainoka, Makakahi, and Ruamahanga catchments of the northern Tararua Ranges. Short-jawed kokopu were not recorded in any of the Ruamahanga sites, despite there being comparable habitat to the other two catchments surveyed. Bowie and Henderson commented that a barrier to migration in the lower catchment was the most likely reason for the apparent lack of short-jawed kokopu in the headwaters. While they suggested that "some pollutant" in the lower reaches may be responsible, this diadromous species is the only category A fish in Department of Conservation's threatened species list[4], and it is noted that sightings have usually been made in smallish streams surrounded by unmodified broadleaf/podocarp forest, and in pools with very thick vegetation cover. High summer water temperatures and lack of cover in the lower-middle Ruamahanga are certainly not conducive to their survival.

Watts and Perrie (2007) recently reported on instream flow issues as the first stage of the Lower Ruamahanga instream flow assessment. They proposed two (relevant to the MWTP Upgrade) instream flow objectives for the Lower Ruamahanga, being:

- to ensure adequate water depth for migratory fish passage and recreational boating; and
- to ensure sufficient habitat is maintained for fish, in particular brown trout.

Watts and Perrie document the ecological values of the Lower Ruamahanga with respect to fish and note that low flows can have an indirect effect on these values due to further impairment of water quality during times of low flow. They also noted that habitat quality decreases with distance downstream in the Ruamahanga mainstem (also noted in the AEE), and that there are a number of reasons for this, including a large number of point source discharges as well as non-point source (diffuse) discharges from the high degree of agricultural land use. The fish experts present on a field trip organised by GW as part of the instream flow studies considered that low dissolved oxygen, high water temperatures, and nutrient enrichment were their key concerns.

As Watts and Perrie note, there is no continuous dissolved oxygen or water temperature data. However, it should be emphasised that there is no evidence that the current MDC discharge is linked with either low DO or high temperatures, and the effect of the existing discharge on nutrient loads is minor compared with other sources (though major at low flows). The proposed upgrade will remove Masterton effluent-derived nutrients from the river at this time when river flows (as a source of dilution) will be at their lowest.

The information presented in the AEE, as well as the above supplementary information, indicate that low flows and high summer water temperature in the mid-lower main stem of the river are the main factors influencing fish distribution and habitat in the Ruamahanga and that the existing Masterton WTP discharge has minimal effect. The proposed upgrade will decrease this minimal effect still further by removing treated effluent from the river at times when any effect could be expected to be maximised.

3 More so than the native fish species mentioned above - see Table 13.6 in Hickey 2000.

4 Refer to http://www.mfe.govt.nz/publications/ser/ser1997/html/chapter9.7.3.html

Reference cited in AEE

Hickey, C.W. (2000). *Ecotoxicology: laboratory and field approaches*. In: "New Zealand Stream Invertebrates: Ecology and Implications for Management": KC Collier; M Winterbourn, ed. New Zealand Limnological Society, Christchurch, New Zealand. pp. 313-343.

Additional references (not in AEE)

Bowie, S and Henderson, I (2002) *Shortjaw kokopu (Galaxias postvectis) in the northern Tararua Ranges Distribution and habitat selection* DoC Science Internal Series 30 21 pp.

Watts, L. and Perrie, A (2007) *Lower Ruamahanga River instream flow assessment*

Stage 1: Instream Flow Issues Report, Greater Wellington Regional Council. Environmental Monitoring and Investigations Department. Report no. GW/EMI-G-07/135 53 pp

17. Information Requested

What are the predicted in-river dissolved reactive phosphorus (DRP) concentrations 200m, 300m, 400m and 800m downstream of the diffuser outfall at just above median river flow?

Reason:

Table 29 (p.123 of AEE) only predicts in-river concentrations at various distances downstream for soluble BOD, ammoniacal nitrogen and nitrite and nitrate nitrogen. DRP concentrations also need to be predicted (based on both the existing 95th percentile effluent concentration and the 90th percentile compliance concentration being sought) as DRP is the likely limiting nutrient in the Ruamahanga River.

RESPONSE

The predicted in-river concentrations at 200m, 300m, 400m and 800m downstream of the diffuser outfall are 0.22, 0.18, 0.16, and 0.13g/m^3, respectively.

It also needs to be noted that discharge at just above median flow will be transitory. The discharge regime model (Table 24, p100 AEE) predicts, for example, that discharge to the river will occur only 8% of the time in January (2.4 days) and this includes all flows above median flow. Accordingly the proportion of time when the concentrations are high and river flows are relatively low (just above median) is very low.

Characteristically, very rapid increases in flow occur in this part of the Ruamahanga River in summer, with low-flood flow conditions transitioning in only a few hours (see Fig 29 - p119 AEE). Thus the actual environmental effect (when P is actively being taken up by periphyton under threshold conditions) would be very small and would occur when algal periphyton are being scoured by flood conditions (see Ruamahanga measurements in Figure 5.2 of NIWA 2003).

This is illustrated in the discussion under the response to Question 22 below.

A higher P discharge will occur when the River is greater than median flows (in practice in order to be greater than median flows for a day – a proposed consent requirement – the River will need to be >> median flow for most of the discharge period) but under this scenario there will also be a greater P load from upstream diffuse sources, the River will be turbid, and periphyton will be stressed by low light and hydraulic scouring. Therefore the actual impacts on the river due to the WWTP discharge will be greatly reduced compared with the before upgrade situation.

We do not expect that there will be any significant downstream issues with the transport of pond nutrients during the flood events. For example, travel time for the 98km from Wardells Bridge to the sea is approximately 44h at a flow of 12.3m^3/s, decreasing to 17h at 75m^3/s and to 12h at 143m^3/s, based on the velocity relationships measured at Wardells. The absence of downstream lakes, together with the unfavourable conditions for periphyton growth as noted above, will therefore not result in significant downstream periphyton stimulation.

18. Information Requested

What data (number and date range) are the 95th percentile effluent concentrations listed in Table 29 (p.123 of AEE) based on? Also, what are the predicted in-river contaminant concentrations based on the effluent percentile compliance standards sought in Table 46 of the AEE?

Reason:

The values given in Table 29 are not from Table 5 (p.41) and Table 5 does not contain any data for soluble BOD, nitrite nitrogen or nitrate nitrogen. The value for soluble BOD (6.1mg/L) is less than half the 90th percentile value (14.5mg/L) quoted in NIWA's (2006) percentile standards memorandum and less than a quarter the 90th percentile compliance standard sought in Table 46 (28mg/L). It is important to know what data have been used in predicting in-river contaminant concentrations downstream to ensure that they reflect the likely worst-case (95th percentile) effluent discharge. Therefore where you are seeking 90th percentile standards that are higher than the existing 95th percentile effluent concentrations, these proposed standards also need to be used to predict the worst-case in-river contaminant concentrations.

RESPONSE

The soluble BOD_5 was calculated as noted in table footnote in NIWA (2007) – "Pond and leakage BOD uses a 22% factor to convert measured total carbonaceaous BOD5 to soluble BOD (ref Davies-Colley et al 1995); (BOD 95% = 28g/m^3; median = 17g/m^3). It was an oversight at the time not to incorporate the measured sBOB data from the summary spreadsheet as used for percentile derivation.

The fraction of sBOD of total carbonaceous BOD for the Masterton ponds (n = 16) is 31% for median and 90% for 95%ile, which is higher than the larger New Zealand pond dataset.

This has been corrected below with additions as requested, with simulation for the 'as measured' 95%ile values and for the compliance monitoring 90%ile values. The table below provide the in-river predictions for the effluent + leakage and the leakage alone.

Phosphorus predictions are now included for the effluent + leachate scenario. However, as noted in the response to Question 17, the additional phosphorus concentration input at the time of flows above median will not be expected to contribute to increased algal growths. This is because the hydraulic bed scour during the flood events, combined with the increased turbidity and depth will prevent algal growths occurring.

Table Q18.1: Mixing region scenario: Use upstream median, leakage median and Discharge 95%iles

<u>Inputs</u>

Flow	12.33m^3/s	Effluent dilution	30
Leakage dilution	221	Mixing scenario for:	4 pipes; 0.5m dia; 0.52 m/s to median flow

Concentrations (g/m³)					Distance downstream of outfall (m)					
Parameter	Median Upstream	95%ile Effluent	Median Leakage	Guideline	200	300	300% GL	400	800	800% GL
fBOD	0.3	28	5	2.00	1.92	1.67	83%	1.45	1.26	63%
NH-4N(S)	0.01	11.3	1.1	1.61	0.66	0.56	34%	0.47	0.39	24%
NH4-N(W)	0.01	11.1	6.7	1.61	0.66	0.56	35%	0.47	0.40	25%
NO2-N	0.002	2.01	0.14	9.00	0.12	0.10	1%	0.08	0.07	1%
NO3-N	0.5	4.29	0.84	7.20	0.75	0.71	10%	0.68	0.65	9%
DRP	0.01	3.3	2.7	0.030	0.22	0.18	615%	0.16	0.13	441%

- *Modified Table from NIWA (2007). Uses upstream background concentrations with leakage (2400 m3/d; 221x to half-median flow, summer; 443x dilution to median flow, winter). Receiving water targets provided in Table 27.*
- *RWT = receiving water target*

Leachate only (summer contribution calculated for half-median flow)

Table Q18.2: Mixing region scenario: Use upstream HALF median & leakage median

Leakage dilution 221

Concentrations (g/m³)					Distance downstream of outfall (m)					
Parameter	Median Upstream	95%ile Effluent	Median Leakage	Guideline	200	300	300% GL	400	800	800% GL
fBOD	0.30	0	5	2.00	0.34	0.33	17%	0.33	0.32	16%
NH-4N(S)	0.01	0	1.1	1.61	0.02	0.02	1%	0.02	0.01	1%
NH4-N(W)	0.01	0	6.7	1.61	0.061	0.053	3%	0.047	0.040	3%
NO2-N	0.002	0	0.14	9.00	0.003	0.003	0%	0.003	0.003	0%
NO3-N	0.5	0	0.84	7.20	0.51	0.51	7%	0.50	0.50	7%
E.coli(S)	103	0	200	130	105	104	80%	104	104	80%
E.coli(W)	49	0	260	130	51	51	39%	50	50	39%
DRP	0.010	0	2.7	0.030	0.031	0.027	92%	0.025	0.022	74%

Scenario for proposed effluent compliance standards (Table 46 of AEE)

Table Q18.3: Mixing region scenario: Use upstream median, leakage median and effluent compliance 90%iles

Inputs

Flow 12.33 m³/s Effluent dilution 30

Leakage dilution 221 Mixing scenario for: 4 pipes; 0.5m dia; 0.52 m/s to median flow

Concentrations (g/m³)					Distance downstream of outfall (m)					
Parameter	Median Upstream	90%ile Effluent percentile compliance standard	Median Leakage	Guideline	200	300	300% GL	400	800	800% GL
fBOD	0.3	28	5	2.00	1.92	1.67	83%	1.45	1.26	63%
BOD	1	43	17	5*	3.56	3.16	63%	2.82	2.51	50%
NH-4N(S)	0.01	11	1.1	1.61	0.64	0.54	34%	0.46	0.38	24%
NH4-N(W)	0.01	11	6.7	1.61	0.68	0.58	36%	0.49	0.41	25%
NO2-N	0.002	1	0.14	9.00	0.06	0.05	0.6%	0.04	0.04	0.4%
NO3-N	0.5	7.5	0.84	7.20	0.93	0.86	12%	0.81	0.75	10%
SS	1	91	23	10*	6.32	5.48	55%	4.78	4.14	41%
DRP	0.01	3	2.7	0.030	0.20	0.17	568%	0.15	0.12	407%

* = default receiving water criteria values from: Hickey, C.W.; Quinn, J.M.; Davies-Colley, R.J. (1989). Effluent characteristics of domestic sewage oxidation ponds and their potential impacts on rivers. *New Zealand Journal of Marine and Freshwater Research 23*: 585-600.

19. Information Requested

What are the expected 90th/95th percentile E.coli counts post-proposed upgrade and therefore the expected in-river E.coli counts after reasonable and full mixing at just above median river flows?

Reason:

The predicted downstream E.coli counts have been based on the expected median count post-upgrade which is not considered to be a conservative modelling approach.

RESPONSE

Predicted downstream E.coli counts have **not** in fact been based on the expected median count post-upgrade. Footnote No. 2 on both Tables 32 and 33 of the AEE has led to confusion, and hence the question above. While the footnote is correct in saying that the median value is based on a median effluent concentration, what it does not say is that the 5-95%ile values (both given in brackets) are based on Monte Carlo distributions (the equivalent percentile value for both upstream and the effluent). Thus, the 95%ile values (1012 and 1014 cfu's/100mL at 300m downstream and at Wardell's respectively) have been modelled using the 95%ile effluent E.coli value.

20. Information Requested

What is the reason for the predicted 52% increase in DRP concentration during a river discharge post-upgrade of the oxidation ponds (Table 37, p.128 of AEE)?

Reason:

This represents a significant increase in DRP but the reason and significance of the increase in terms of potential effects on the river are not explained in the text.

RESPONSE

The reason for the predicted 52% increase in river DRP concentration post-upgrade is simply that, on days when discharge can occur, there will be at least 410 L/s of treated effluent (1:30 ratio at >median flow) compared with the current averaged discharge rate of 180 L/s.

21. Information Requested

Please provide the predicted in-river DRP concentration after reasonable mixing at the 'threshold flow range' when a discharge to the river is initiated (Table 38, p.135 of AEE).

Reason:

As per 22 above relating to Table 29, the predicted DRP concentration has not been provided and is considered very relevant.

RESPONSE

The answer is provided in the response to Question 17 above (see footnote (a) to Table 38 AEE in terms of relevance[5]). The threshold flow range occurs for about 4% of all summer flows (see Figure 30). This threshold represents about 13% of the total time when effluent could be discharged to the river. If January is taken as an example, where direct discharge is predicted for only 2.5 days (Table 24, p100 AEE), then the threshold flow (12.3 -14.0m3/s) could be expected for 13% of these 2.5 days (= .325 days) or approximately 8 hours for the whole of January.

At the proposed point of reasonable mixing of 300m, the predicted in-river DRP concentration after reasonable mixing at a flow just above median is 0.18g/m^3.

22. Information Requested

What are the existing and predicted median, mean and maximum (95th percentile) nutrient and soluble BOD loads to be discharged to the Ruamahanga River on a daily basis at just above median river flow and during a worst-case maximum volume discharge? Also, over a typical year what is the mass load (tonnes/year, soluble and total) of nitrogen and phosphorus that will be discharged to the river?

Reason:

Your assessment of the effects of the effluent and pond seepage discharges on the river is based on contaminant concentrations only. Concentrations alone do not indicate the complete picture of effects as they do not take into account discharge volume. In responding to the question above, please clearly specify the date range for the existing effluent data and the effluent volumes used in the calculations. To represent the worst-case effluent discharge scenarios, it is expected that the minimum dilution (30 x) will be used for both the discharge at just above median river flow and the discharge at the maximum possible rate (1,200 L/s).

RESPONSE

The existing median, mean and maximum (95%ile) nutrient and soluble BOD concentrations were calculated from the compliance monitoring record (May 03-Jun 07). This data is presented in Table Q22.1 below, together with the number of observations from which the statistics were calculated.

In cases where values were below detection limit, a value of half that value was used in calculations.

Table Q22.1: P, N and Soluble BOD Statistics of Effluent (from Compliance Records) – all g/m^3

	Mean	Median	95%ile	n
TP	3.03	2.86	4.0	53
TN	10.6	10.9	16.8	55
Sol BOD	5.2	3	15.1	63

Daily loads (Table Q22.2 below) were calculated from the product of the above table with corresponding flow statistics (a mean of 13,944m^3/day, a median of 12361m^3/day, and a maximum 74937 m^3/day). While this is not strictly correct in the case of 95%ile load, it serves to illustrate a worst case.

[5] Note, the reference in this footnote to Figure 28 is incorrect, it should be Figure 30.

Table Q22.2: Estimated P, N, and Soluble BOD loads (existing in kg/day)

	Mean	Median	95%ile
TP	42	35	300
TN	148	134	1258
Sol BOD	73	37	1131

Predicted daily loads at just above median flow (Table Q22.3 below) were calculated using the same concentration data (no change expected from existing quality – refer to Table 22 AEE), but assuming that when discharge is occurring, it is at a rate of at least 410 litres/sec (allowing for a minimum 30x dilution)

Table Q22.3: Predicted P, N, sol BOD at just over median flow (kg/day)

	Mean	Median	95%ile
TP	106	100	140
TN	371	381	588
Sol BOD	182	105	528

The worst case maximum discharge (Table Q22.4 below) was calculated using the maximum possible discharge rate (1200 l/s) equivalent to 103,680m^3/day).

Table Q22.4: Predicted Maximum P, N, Soluble BOD Loads (kg/day)

	Mean	Median	95%ile
TP	314	296	415
TN	1100	1130	1741
Sol BOD	539	311	1565

In order to calculate mass load discharged of nutrients discharged over a typical year (Table Q22.5 below), the simulations of average daily discharge (Table 24 AEE) was multiplied by the average (mean) TP and TN concentration given in the Table above (3.03 and 10.6 g/m3, respectively). This gives an average daily load discharged to the river for each month from which an average annual load can be estimate. In order to compare with the 'before' upgrade' situation we used this same data (Table 24 AEE) but assumed that the effluent load entering the river would be the sum of land + river discharges.

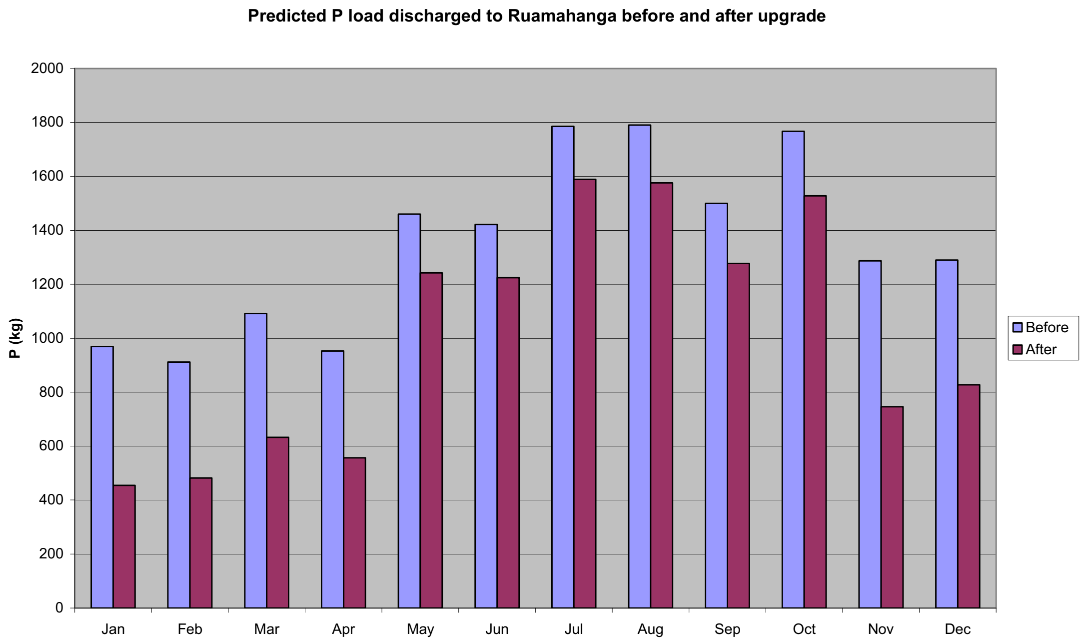
Table Q22.5: Estimated average annual P and N loads discharged to the river before and after the upgrade (tonnes)

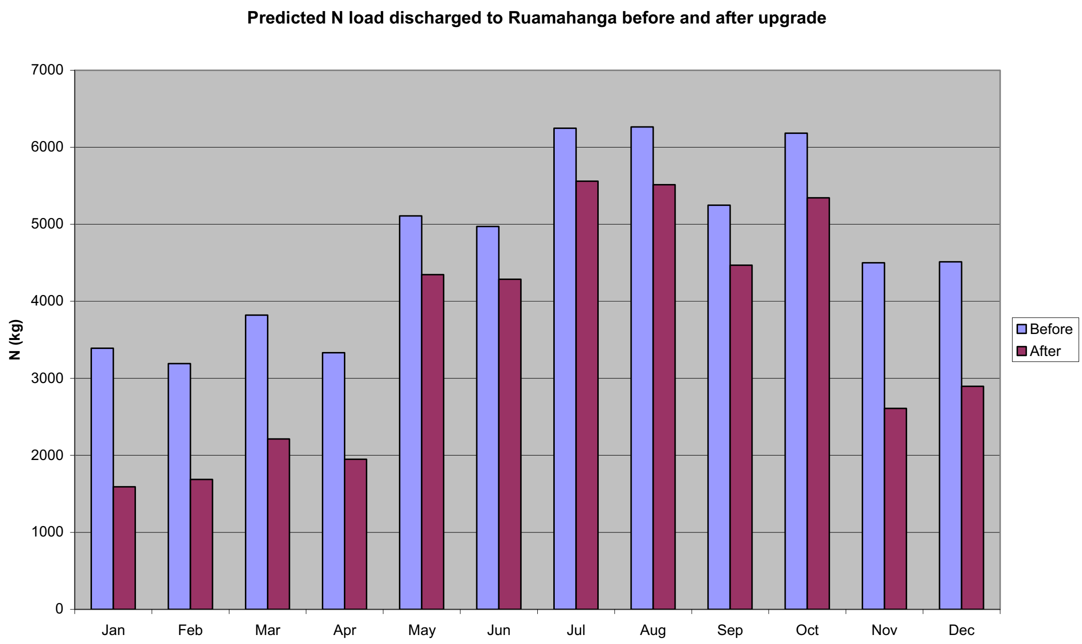
	Before upgrade	After upgrade
TP	16.2	12.1
TN	57	42

- *Note on average DIN (NH4-N +NO3 +NO2-N) is ~80% of TN and DRP is ~ 70% of TP*

The reduction in nutrient load is, however, distributed unequally throughout the year, with greater reductions in summer (when effluent is dominantly irrigated). The Figures below illustrate the 'average' monthly TP and TN loads before and after the upgrade.

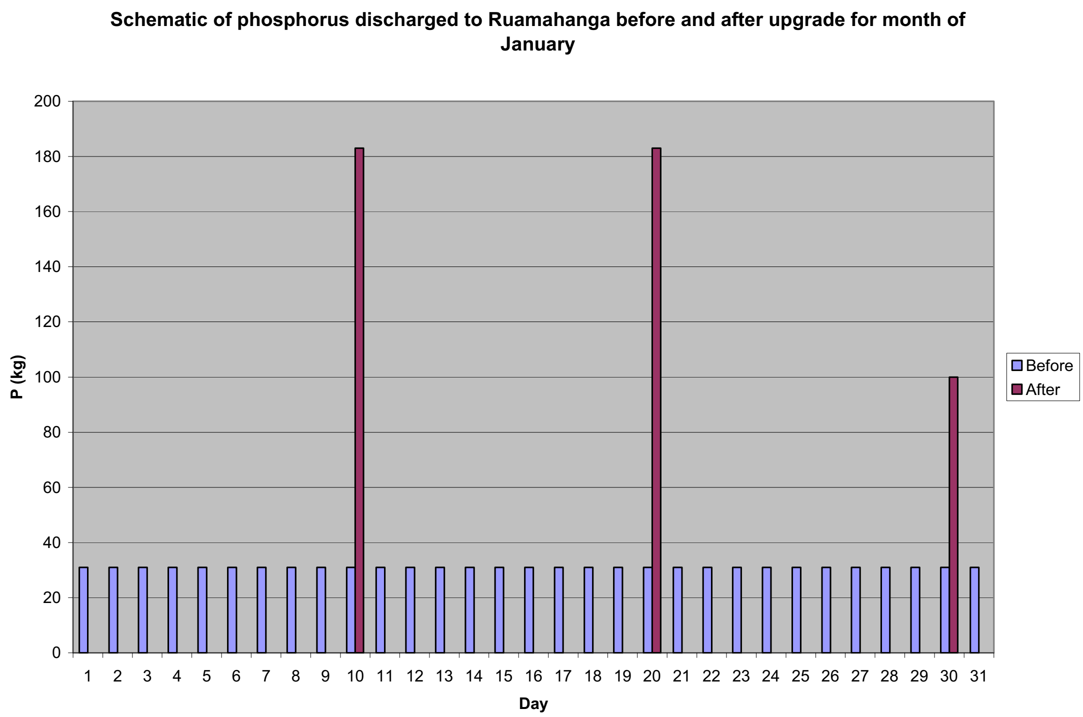
Figure Q22.1: Predicted P and N Loads to River Before and After Upgrade





However, even these average monthly figures do not accurately reflect the operational regime, which will see, for example, the entire monthly P load for January discharged over 8% of the time (over median flow). An illustrative phosphorus discharge regime for January is shown below. Note that the bars for "after" upgrade are not visible for 28 out of 31 days in January because there will be no discharge during these days.

Figure Q22.2: Phosphorous Discharged to River During January Before and After Upgrade



Thus in summer, when the potential for periphyton growth is highest, the River will receive no direct discharge of phosphorus from the WWTP for ~ 87% of the time (see Table 23 AEE). See also the discussion in the response to Question 17 above.

23. Information Requested

Please recalculate compliance with the MfE/MoH (2003) microbiological water quality guidelines for freshwater recreational areas, using an amber/alert E.coli value of 260 cfu/100 mL (p.77 of AEE).

Reason:

The alert value used relates to beach grading. It would be useful to see the degree of compliance with the actual alert and action guidelines (260 and 550 cfu/100 mL respectively) both upstream and downstream of the discharge.

RESPONSE

Page 77 of the AEE incorrectly states that 130 cfu/100mL relates to bathing water guidelines 'alert levels'. In fact, the threshold relates to a NCRL (no-calculated risk level) of one case of Campylobacter infection per 1000 exposures (see Table H2 MfE/MoH guidelines). However, to answer the question above, the complete record has been reanalysed and the exceedances of the MfE/MoH guidelines are given in Table Q23.1 below.

Table Q23.1: Exceedance of MfE/MoH guidelines above and below the existing discharge (December 1999-June 2007)

Guideline	RUA1 Upstream number of exceedances n=165 (% exceedance)	RUA2 Downstream number of exceedances n=148 (% exceedance)
>130 cfu/100 mL	41 (25%)	78 (53%)
>260 cfu/100mL	25 (15%)	37 (22%)
>550 cfu/100mL	14 (8.5%)	22 (15%)

24. Information Requested

Please provide detailed comment and supporting analysis of the cumulative effects of all three discharges (pond seepage, land disposal and direct river discharge) on the Ruamahanga River.

Reason:

All three discharges enter the river either directly or indirectly yet the AEE makes no attempt to look at the cumulative effects of the combined discharges on receiving water quality. For example, Table 29 does not consider possible leaching effects of effluent discharged to land and the effects of the river and pond discharges on periphyton growth (p.113 and p.130 of AEE) do not take into account the dissolved nutrient contributions from contaminated groundwater beneath the land disposal field.

RESPONSE

It has already been established that the principal potential environmental effect relates to phosphorus and periphyton growth. As the above question also seems to be directed towards this effect, the response focuses on this aspect.

Periphyton is only an issue in the Ruamahanga during summer months, so the analysis can be further reduced to the period 1 November-30 April.

The following points of relevance to this question have already been discussed in Questions 17, 18, 20, 21, and 22:

- The effects of DRP discharges from the scheme (on periphyton growth) will only be significant under summer low flow (< median flow) conditions.
- There will be no direct discharge of treated sewage effluent under such conditions.
- Under ‘fresh’ or ‘flood’ conditions, the discharge of DRP from the scheme will have no significant environmental effect because catchment-induced turbidity will prevent DRP uptake from periphyton, which will be scoured by flood flows in any case. The relatively short travel time to the sea will ensure that DRP is flushed from the River, thus there will be no significant residual effect once the River returns to baseflow (<median flow).
- Thus the only period of possible concern is the threshold period when direct discharge may occur (just above median flow)
- The actual total duration of discharge under these conditions will be very short under summer conditions. Using the HortResearch model, it is calculated that, in January for example, discharge under these threshold conditions is likely to occur for ~8 hours per month.
- At this threshold flow, the NIWA developed guideline will be exceeded but because it is so transitory and likely to be followed by higher flows at during which scouring will occur, the

actual environmental effects will be minor.

Based on these factors, the only time where cumulative effects of all three sources of DRP (direct discharge, leakage and groundwater return flow) are at the threshold flow range, which, as discussed above, will be transitory.

Below median flows cumulative effects will be reduced to pond leakage and groundwater return flows, since there will be no direct discharge.

It is noted that the current situation under summer conditions (< median flow) with direct discharge to the river (+ pond leakage) the effects on periphyton growth is considered only minor (see page 79 AEE). Therefore, taking out direct discharge (by far the major source of DRP) to the river during this period will further reduce this minor effect.

The further modelling completed by Pattle Delamore Partners referred to in Question 5 & 6, provides seasonal groundwater concentrations for the irrigation scheme and this has been used to determine the combined effects on the river. The worst case DRP loads discharged to the Ruamahanga River (95 percentile discharge), upper bound pond leakage (both derived from question 18) and long-term (after 28 years) groundwater from irrigation return flow, at just above median flow are summarised in Table Q24.1 below.

This confirms that at just above median flow, direct discharge is by far the major contributor (95%) of DRP, and that by removing the discharge (as will be the case below median flow in summer) there will a large reduction in river DRP concentration. This will further reduce the "minor" effects of DRP on periphyton growths noted with the current discharge regime. The conservative assessment of the increase in DRP as a result of pond leakage and long term irrigation groundwater is to increase DRP concentrations in the river by 0.0065 g/m^3. With background DRP concentrations of 0.01 g/m^3, total DRP is predicted to increase to 0.0165 g/m^3 downstream of the ponds as a result of pond leakage and irrigation groundwater. This is lower than the guideline value of 0.030 g/m^3.

Table Q24.1: Predicted worst case DRP discharge to River from direct discharge, pond leakage and groundwater (irrigation return flow) at just above median flow

Component	DRP mass (kg/day)	Change in fully mixed River DRP concentration (g/m^3)
Direct discharge	117	0.11
Pond leakage	6.5	0.006
Groundwater (from irrigation)	0.5	0.00048
TOTAL	124	0.117

25. Information Requested

Please comment on the appropriateness of using the existing upstream sampling site as an ongoing control site (p.116 of AEE).

Reason:

The extent of the proposed land disposal area and direction of groundwater flow under the disposal field suggests that the existing upstream sampling site may be influenced by contaminated groundwater.

RESPONSE

We agree that it would sensible to move the upstream control site (RUA1) from its present location to upstream of the irrigation area.

26. Information Requested

Please clarify the flow duration at which the trigger for discharge to the Ruamahanga River in summer is to apply and comment on how the impact of the discharge on the river flow will be accounted for in the trigger flow rates given that the Wardell's Bridge flow recorder is located downstream of the point of discharge.

Reason:

A mean daily flow trigger is possibly more appropriate and manageable than an instantaneous trigger flow. A system would need to be set up to subtract the discharge volume from the recorded flow at Wardell's Bridge. This system would need to account for the potential error rate (up to 10%?) in measuring the discharge volume (and possibly river flow).

RESPONSE

Operationally, a mean daily flow trigger would not work in this river because of the very peaky nature of the hydrograph (see Figure 29 AEE) and the inherent delay before a daily flow value can be obtained. It will be necessary to start to discharge to the river on most occasions when the hourly flow exceeds the trigger value and there is a reasonable likelihood of the river flow being sustained for more than six to twelve hours above the trigger value, which is the case for about 90 % of "freshes" during summer.

A predictive model will be used "to overview" the discharge operation, to give more certainty that the exceedance of median flow, will be sustained for a sufficient duration. This will avoid discharging when the river flow exceeds the trigger value for durations of less than about six hours. A similar model for flood warning purposes has been developed by NIWA for the Ruamahanga River, which uses real time monitoring and meteorological forecasting to calculate the predictions (the minimum 35,000 m^3/day discharge rule referred to in the AEE is no longer proposed as the means to achieve this).

The key proposed operating constraints are the minimum 30:1 dilution rule for all discharges and discharge only above median river flows (12.33m^3/s) in the summer period. The hourly flow measurements at Wardell's Bridge will be telemetered to the MWTP for discharge control based on the proposed discharge rules for summer of (i) no discharge below median river flow, and (ii) a minimum dilution of 30:1 to be maintained at all times. The MWTP contribution to the river flow will be automatically taken into consideration. On all occasions when the river flow drops below the trigger value, the discharge will stop automatically.

The hourly flow data for river flow has been analysed and for virtually all freshes, the river flow rate increases very rapidly. A "start to discharge" delay of 15 to 30 minutes will ensure that the river flow has comfortably exceeded the trigger value, thus overcoming any minor errors in the flow measurement data.

Flood Protection Works

27. **Information Requested**

Please provide an analysis on the potential flooding effects on neighbouring properties, particularly on the left bank of the Ruamahanga River, as a result of the proposed upgrade to stopbanks and erosion proofing of installations. Also what will be cumulative effect on these properties during flood events in both the Whangaehu and Ruamahanga Rivers as a result of the proposed upgrade to stopbanks.

Reason:

There is limited information in the AEE to show the impact on neighbouring properties resulting from diverted floodwaters with the proposed stopbank upgrade. A number of submitters have raised concerns about this matter.

RESPONSE

Further modelling of the Ruamahanga River comparing the pre and post stopbank upgrade show that the estimated increases in river levels 100 year flood are 60mm in the vicinity of the oxidation ponds, and increase to 80 to 90mm downstream of the oxidation ponds to Wardells Bridge. Given the small increase in river levels as a result of the stopbank upgrade, there would be little additional effect of flooding at properties on the left bank opposite and downstream of the oxidation ponds. Floodable land is on the lower terraces and flood flows would be contained within the stop banks.

The modelling incorporated a peak flow in the Ruamahanga River with a 100-year return period combined with floor flows in the Whangaehu River with a 2-year return, and in the Waipoua River with a 10 year return, all occurring at the same time. This is the same approach used in the Wellington Regional Council report "The Upper Ruamahanga River & Floodplain Investigation; Phase 1 - Issues" (1995). For the Whangaehu, Waipoua, Kopuaranga and Ruamahanga Rivers to have coinciding 100 years floods would give a total flow of 1319 cumecs and would be a 0.02% or 1 in 5000 year flood event at Wardells Bridge.

The effect of installation of erosion protection only has a minor affect on flood levels in the main channel and does not affect the high flood levels which are outside the main channel. Rock protection is advantageous compared to vegetation along the banks due to its comparatively lower roughness.

Minor Pieces of Information Required

28. **Information Requested**

How many sample results are the data in Tables 3-4 (p.40 of AEE) based on and over what date range?

Reason:

Without this information it is not clear how representative the data are of typical influent quality.

RESPONSE

Data for the raw wastewater (Table 3 AEE) is from the November 2005 characterisation and are the average results made up of 24-hour composite samples on 7 days.

Data for raw wastewater metal concentrations (Table 4 AEE) is for one 24 hour composite sample taken on the 19 July 2000.

29. Information Requested

How many sample results are the pre- and post maturation cell E.coli counts based on (Tables 3-4, p.40 of AEE) and over what date range?

Reason:

Without this information it is not clear how effective the upgrade has been in reducing E.coli counts in the final discharge.

RESPONSE

Wastewater influent characterisations have been carried out over one week periods in July 2000, February/March 2005 and November 2005: i.e., one prior to the interim upgrade and two following the upgrade.

The upgrading with a further maturation cell occurred in 2003 and there were 33 E.coli samples taken prior to the upgrade and 36 samples following the upgrade.

30. Information Requested

How many influent samples were collected in November 2005 (Table 7, p.42 of AEE) and why is the date range for effluent data used here different from Table 5?

Reason:

The number of influent sample results will influence the reliability of the calculated effluent treatment performance. Using different date ranges (and statistical measures of median vs. mean) is confusing.

RESPONSE

The influent data characterisation included 24-hour composite samples on 7 days. While Table 7 of the AEE could have been updated to include the same period as Table 5, the difference between the 12 years and 10 years of data is minimal.

31. Information Requested

Please provide a clearer Figure 20 (p.83 of the AEE).

Reason:

It is not possible to read the writing on Figure 20.

RESPONSE

Figure 20 is included in Appendix G. We have also updated the figure to indicate the changes to border strip irrigation over the whole area, the native bush area not being irrigated and the 2 ha area of land at the north of the property not being irrigated.

32. Information Requested

Please clarify the two figures provided for ammoniacal nitrogen in Table 22 (p.97 of AEE).

Reason:

It is not clear whether the geomean has gone up following the recent pond upgrade.

RESPONSE

The (pre and post upgrade) in the heading for Table 22 refers to the proposed future upgrading to further cells-in series as shown in Figure 20. The upgrading in 2003 was not intended to significantly influence the ammonia nitrogen and the data has not been analysed to compare pre and post 2003 data.

The table shows the existing effluent ammonia -N summer geomean (0.7g/m^3) and the winter geomean (3.0g/m^3) for data from 1994 to 2006 and similar summer and winter values for Ecoli.

33. Information Requested

Please provide a clear map of the soils on the site.

Reason:

p.51 of the AEE refers to Figure A3.1 in Appendix A3 but it is not possible to read the writing on this figure.

RESPONSE

The text in the AEE refers to the extent of the soils investigations on the site which is shown on Figure A2.1 (not Figure A3.1 which shows the irrigation site layout). The soil types are shown on the Landcare Research plan Appendix 1a to 1e, which are included in Appendix H.

34. Information Requested

Please provide a clearer link between the Table 49 in the AEE and Figure A2.1 in Appendix 2 regarding the position of proposed monitoring bores.

Reason:

It is unclear in the map provided what bores will be monitored.

RESPONSE

A plan showing only the proposed groundwater monitoring bores is included in Appendix I.

Boffa Miskell

Appendix A

Section 13.3.5 from *New Zealand Wastewater Monitoring Guidelines* on Statistical Approaches for Designing Compliance Rules (September 2002)

13.3.5 Statistical approaches for designing compliance rules

Sampling error

The heterogeneous nature of the sampled wastewater means that small and infrequent samples of the discharge will exhibit variability. Statisticians call this 'sampling error' – but that does not mean that an error has been made in sampling! If an error is made in the sampling or in analysing the sample's contents this is known as 'measurement error'.

Percentile standards or maximum limits?

In setting a discharge monitoring standard one is interested in some critical concentration of a contaminant (e.g., nitrogen, suspended solids, a bacterial indicator) derived from toxicity, ecological or epidemiological studies. These critical values are never known precisely – their derivation always calls for an element of value-judgement, and recognition that the scientific studies upon which they are based are not absolute in their findings. Because of this, there is increasing use of percentile standards, in which concentrations may exceed the critical value for some proportion of the time (typically 5%, in which case we have a 95%ile standard, and/or 50% for a median standard). The case for percentile standards, rather than maximum standards, is made stronger when one recognises two mechanisms that may give rise to results that are too high (rather than too low):

- The occasional presence of sample contamination or laboratory error.
- The at-times heterogeneous nature of effluent treatment processes and therefore effluent quality (e.g., some parcels of an effluent stream may not have been as effectively sterilised by UV lamps, and so are rather higher in their concentration of a bacterial indicator than is the bulk of the fluid).

When we consider the statistical 'sampling error' along with percentile standards we *must* consider 'burden-of-proof' issues. For example, see Figure 13.2, showing a hypothetical situation in which we actually know the true 95%ile concentration (i.e., 60 units – we never do know it of course, but the Figure will be instructive). Figure 13.2a shows a situation where the *sample* 95%ile (63.5 concentration units), calculated using some standard formula (see Appendix 1) is greater than this true value of the continuous discharge. But for another determination as shown in Figure 13.2b the *sample* 95%ile (58.2 concentration units) is lower than the true value. Either situation can occur. And because in practice we do not ever know the true value, we always are uncertain about whether the true value is above or below our sample-statistic value. This is where the burden-of-proof issue arises, in which either the 'producer's' risk (i.e., discharger's risk) or the 'consumer's' risk (i.e., environment's risk) may be kept small. They *cannot* both be made small. These two approaches are characterised as the 'benefit-of-doubt' and 'fail-safe' approaches respectively (Ellis 1989; McBride 2000a; McBride et al. 2000).

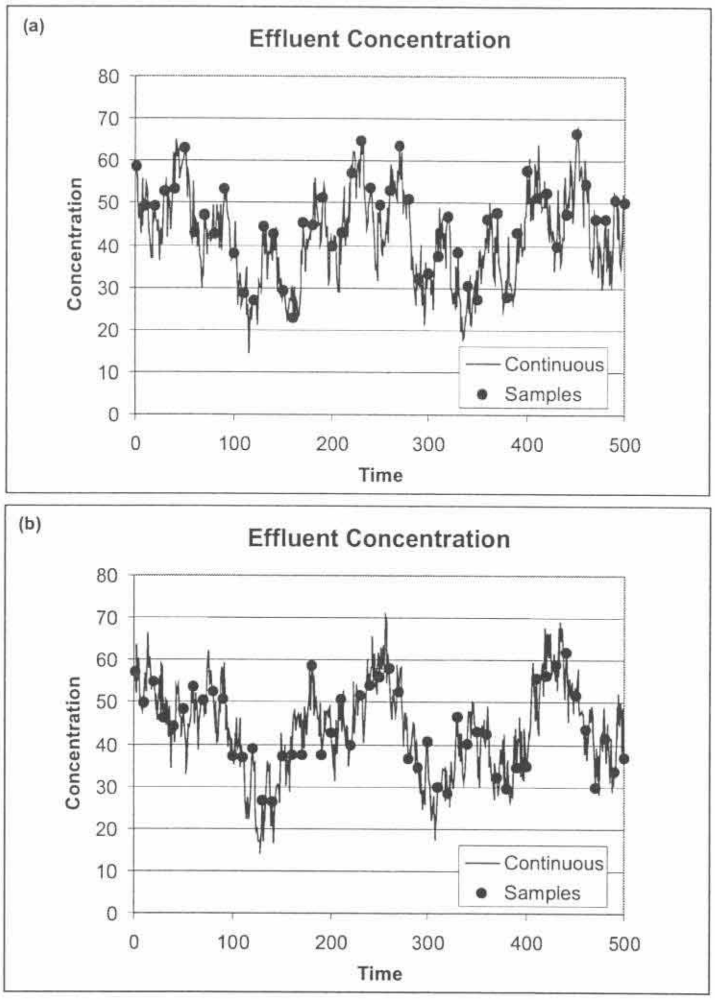


Figure 13.2: Two scenarios of a 'continuous' time series of a discharge concentration with a true 95-percentile concentration of 60 units, but have then been grab-sampled at a time spacing of 10 time units, where: (a) the 95-percentile of sample concentrations is >60 (i.e., 63.5); and (b) the 95-percentile of sample concentrations is <60 (i.e., 58.2). (from McBride et al. 2000).

If one or the other risk is desired to be kept small – where the discharger or the environment is given the benefit-of-doubt – some calculation procedures are available. These may be somewhat complicated and require certain assumptions to be made about the statistical distribution of the effluent quality, posing further difficulties – especially when little previous monitoring data is available. A third approach is to ignore 'sampling error' and assume the samples measured completely represent the characteristics of the continuous waste stream. Sometimes the sample statistic will be below the true value and sometimes it will be above the true value (as in Figure 13.2). This is called the 'even-handed' approach, because it treats both risks equally. It leads to discharge monitoring compliance conditions couched in terms of sample percentiles. For example:

Based on no fewer than 20 samples on separate days over 3 months, the median concentration of faecal coliform bacteria of the samples shall not exceed 2000 MPN per 100 mL, and no more than 10% of samples shall exceed 8000 MPN per 100 mL.

Proportional compliance conditions

A simpler approach to operate with is to consider instead the permissible proportion of exceedances of a percentile limit in a batch of samples. This is much more easily understood by all parties (public included), as it lends itself to simple tabulation. There are two further advantages:

1. No assumptions about the distribution of the effluent quality data are needed (because the probability of pass or fail in a fixed number of random samples always follows the binomial distribution i.e., a 'heads or tails' situation discussed in most elementary statistics texts);

2. It is immediately obvious when the standard has been breached (i.e., more than the permissible number of exceedances have occurred); there is no need to wait until the end of the compliance assessment period to make that decision and to seek to mitigate the problem.

Often, discharge monitoring conditions are based on a mixture of a 50%ile concentration limit (i.e., median) and an upper-percentile limit (80%ile, 90%ile, or 95%ile). Look-up tables (such as Table 13.2) allow one to determine the permissible number of sample exceedances (e) in a compliance period comprising n samples, based on keeping the discharger's risk[1] at no more than 10%. For calculation of other values of the number of samples (n) or the discharger's risk, refer to McBride et al. (2000) and McBride & Ellis (2001).

1 This is the risk that at some future time the discharger will in breach of the consent conditions, by way of the measured samples, when in fact the true 'continuous' effluent concentration is below the percentile limit.

Table 13.2: Number of exceedances (e) out of n samples permitted to meet percentile discharge compliance standards based on a discharger's risk of no more than 10%.

Number of samples taken in monitoring period (*n*)	Number of permitted exceedances (e) for a 10% discharger's risk to meet the performance standards listed.			
	Median (50%ile)	**80%ile**	**90%ile**	**95%ile**
5	4	2	1	1
6	5	2	2	1
7	5	3	2	1
8	6	3	2	1
9	6	3	2	1
10	7	4	2	1
11	8	4	2	2
12	8	4	3	2
13	9	4	3	2
14	9	5	3	2
15	10	5	3	2
16	11	5	3	2
17	11	6	3	2
18	12	6	3	2
19	12	6	4	2
20	13	6	4	2
21	13	7	4	2
22	14	7	4	2
23	15	7	4	3
24	15	7	4	3
25	16	8	4	3
26	16	8	5	3
27	17	8	5	3
28	17	8	5	3
29	18	9	5	3
30	19	9	5	3
31	19	9	5	3
32	20	9	5	3
33	20	10	6	3
34	21	10	6	3
35	21	10	6	3
36	22	10	6	4
40	24	11	6	4
50	30	14	8	5
100	56	25	14	8

Note: These numbers are in fact pessimistic because their calculation is based on the assumption that the effluent is in fact always borderline for compliance. Such an assumption is necessary using standard statistical methods. But in general this assumption is *not true* An alternative (Bayesian) approach to the calculations does not make this assumption and so results in smaller numbers of samples being required (McBride & Ellis 2001). Note that this alternative approach has already been used in the compliance rules in new drinking-water standards (MoH 2000), and will be explained in some detail in the Ministry of Health's forthcoming Guidelines for Drinking-Water Management.

A few examples of 'proportional' consent conditions are listed in Table 13.3 that were adopted for the North Shore wastewater treatment plant discharge consent, based on a discharger's risk of 10%.

Table 13.3: Examples of the 'proportional' discharge compliance standards for the North Shore WWTP, based on a discharger's risk of 10%. The first two components are based on a median limit over a 1-year compliance period, while the indicator bacteria are based on a median and 95%ile over a 3-month (13-week) compliance period.

Constituent	Units	Sample type	Sample frequency	Standard(*)
Total BOD_5	g m^{-3} O	grab	fortnightly	over 1 year, no more than 16 exceedances above 20
Total Nitrogen	g m^{-3} N	grab	monthly	over 1 year, no more than 8 exceedances above 30
Faecal coliforms	cfu/100 mL	grab	3 per week	for any 3-month(1) period, no more than 23 exceedances above 1000 and no more than 4 exceedances above 10000
Enterococci	cfu/100 mL	grab	3 per week	for any 3-month(1) period, no more than 23 exceedances above 100 and no more than 4 exceedances above 1000

(*) Standards for Total BOD_5, TN use 50%ile limits only, the other constituents use both 50%ile and 95%ile limits.

(1) Calendar 3-month period of 13 weeks

13.4 Sampling techniques and times

Composites versus grab samples

For many analytical procedures, the sample collection method is not specified, therefore it needs to be specified in the resource consent conditions or an associated monitoring/management plan.

Composite sampling provides a way of obtaining a representative measure of a continuous effluent stream with a minimum of analytical effort. By bulking multiple sub-samples, individual concentrations are lost, and so the analytical results refer to average concentrations (or loads if sampling is volume-based rather than time-based). In contrast, grab sampling sets out to measure the instantaneous characteristics of the effluent at that particular time and place.

The type of sampling used depends very much on the objectives of monitoring and also the constituent being measured. Where extremes in quality are of concern (as with judging compliance with upper percentile), grab sampling should be used. If, on the other hand, the

Appendix B

Proposed Effluent Quality Compliance and Monitoring Requirements, from Masterton Wastewater Treatment Plant Upgrade Resource Consent Application - Assessment of Effects on the Environment, Section 12.2

12 Proposed Conditions/Restrictions

The following key restrictions are proposed in relation to the operational parameters of the proposed scheme (note: these may be amended during the consent process).

12.1 Resource Consent Conditions

12.1.1 Discharge to Water

Discharge Rate

- During the period November to April (inclusive), there shall be no discharge to the Ruamahanga River when the river flow is less than 12.33 m^3/s as recorded at the Wardells Bridge gauge station.
- During the period May to October (inclusive), there shall be no discharge to the Ruamahanga River when the river flow is less than 6.15 m^3/s as recorded at the Wardells Bridge gauge station.
- The instantaneous discharge rate shall be at least 30x less than the instantaneous flow in the river as recorded at the Wardells Bridge gauge station, up to a maximum of 1200 litres/second.
- Frequency and compliance calculation shall be in accordance from New Zealand Municipal Wastewater Monitoring Guidelines (NZWWA 2002) as indicated in Table 46 and based on the monitoring frequency given and detection limits in Table 47. Compliance with the ANZECC guideline values for chemical contaminants shall be assessed after a 20-fold dilution factor to allow for reasonable mixing.
- The consent holder to adopt the best practicable option to avoid direct discharge to the river other than in accordance with the above.

Discharge Quality

The proposed percentile discharge compliance standards are based on the risk of a 10% exceedance of target values (90 percentile limit) over a 1 year compliance period (Bell et al 2002; NIWA 2006b).The exception is ammoniacal-nitrogen and E.coli , which have different *targets* for summer and winter and non-compliance is accordingly based on exceedances over a 6 month period. Higher (95% percentile) compliance and the addition of a median standard is proposed for the summer period E.coli.

Table 46 Proposed Effluent Quality Compliance

Parameter	Geometric Mean	Percentile compliance standard	Sampling frequency/ No. samples	Compliance (Exceedances over period)
BOD5 (g/m3)	21	42 90%ile	Fortnighly/26	No more than 5 over 1 year
Filtered BOD	10	28 90%ile	Fortnighly/26	No more than 5 over 1 year
Suspended solids (g/m3)	32	91 90%ile	Fortnighly/26	No more than 5 over 1 year
Dissolved reactive phosphorus (g/m3)	3.0	4.0 90%ile	Monthly/12	No more than 3 over 1 year
Total Nitrogen (g/m3)	13	20 90%ile	Fortnighly/26	No more than 3 over 1 year
Nitrate Nitrogen (g/m3)	1.0	7.5 90%ile	Fortnighly/26	No more than 3 over 1 year
Nitrite Nitrogen (g/m3)	0.5	2.0 90%ile	Fortnighly/26	No more than 3 over 1 year
Ammonia-Nitrogen (g/m3)	2.0 (summer) 6.0 (winter)	11 90%ile 11 90%ile	Fortnighly/13 Fortnightly/13	No more than 3 over 6 months No more than 3 over 6 months
E.coli (cfu/100 mL)	300 (summer)	330 median 1800 95%ile	Weekly/26	No more than 16 above 330 over 6 months, and No more than 3 above1800 over 6 months

Parameter	Geometric Mean	Percentile compliance standard	Sampling frequency/ No. samples	Compliance (Exceedances over period)
E.coli (cfu/100 mL)	1,000 (winter)	1,000 median	Fortnighly/13	No more than 9 above 1000 over 6 months
Metals		ANZECC (2000)	Annually	95%ile trigger values
TPH, PAHs, SVOCs, VOCs		ANZECC (2000)	Annually	95%ile trigger values

Note: Geometric means are provided to enable consistency with historical monitoring and trend reporting

Effluent Monitoring

It is proposed that the wastewater monitoring requirements shall be as set out in Table 47 below:

Table 47 Proposed Effluent Monitoring Requirements

Constituent	Monitoring Frequency	Detection Limit
Flow (influent and effluent)	Continuously	10%
PH	As per *E.coli*	0.1 pH
Temperature	Weekly	0.1 Degrees Celsius
Colour and Clarity:		
Suspended Solid	Fortnightly	0.1 g/m3
Total Solids	Monthly	0.1 g/m3
Colour	As per *E.coli*	
Foam and Scum	As per *E.coli*	
Oxygen Demand:		
Dissolved Oxygen	Weekly	0.2 g/m3
BOD5	Fortnightly	0.1 g/m3
Nutrients:		
Total Nitrogen	Monthly	0.1 g/m3
Nitrite-N	Monthly	0.1 g/m3
Nitrate-N	Monthly	0.1 g/m3
Total Kjeldahl Nitrogen	Monthly	0.1 g/m3
Ammonia-N	Fortnightly	0.1 g/m3
Dissolved Reactive Phosphorus	Monthly	0.1 g/m3
Total Phosphorus	Monthly	0.1 g/m3
Metals and Metalloids:		
Cd, Cu, Ni, Pb, Zn, Hg, As, Ag, Cr	Annually	0.001 g/m3
Alkalinity and hardness	Annually	0.1 g/m3
Organics:		
TPH (Total Petroleum Hydrocarbons) PAH (Poly Aromatic Hydrocarbons) SVOC (Semi volatile Organic Hydrocarbons) VOC (Volatile Organic Hydrocarbons)	Annual	0.001 g/m3
Pathogens and Indicators		
E.coli	Weekly (1 Nov -30 April) Fortnightly (1May–31 Oct)	10 Cfu/100mL

Appendix C

Poster on Leeston Wastewater Treatment Plant Upgrading (CH2M Beca)

Leeston WWTP - Successful Consenting and Upgrading

by Humphrey Archer and David Gardiner

Upgraded Leeston WWTP ponds soon after completion. Infiltration basins are to upper left and border strips are lower right.

Bubble-up valves applying treated wastewater to border strips.

At the opening ceremony, Selwyn District Mayor Michael McEvedy performs the official first flush watched by Township Committee Chairperson Lloyd Clausen.

Authors:

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CH2M Beca

Consent Procurement with Active Community Involvement

Prior to upgrading, Leeston WWTP had a single oxidation pond with discharge to 10ha of border-strip irrigated pasture. During average rainfall conditions, the system coped but during high rainfall, inflow to the WWTP increased dramatically due to infiltration and the irrigation area was overloaded, requiring a discharge of partially treated pond effluent to a drain which entered Lake Ellesmere.

This situation was unacceptable and not likely to be reconsented. Consequently, the Leeston/Doyleston Sewerage Project Team was formed in the mid 1990's. It comprised members of the community, ward councillors along with council-appointed consultants, who focused on finding a better alternative for wastewater treatment and disposal that would also take into account future expansion in both townships over a 20 year period.

Proposed wastewater disposal alternatives such as coastal discharge or linking up with the Lincoln or Christchurch sewerage systems were dismissed due to environmental, cultural or cost considerations.

Previous consultants had proposed pumping peak flows from the existing oxidation pond to remote sites and application to land by spray irrigation. However, both proposals failed their consent applications, because the treatment standard was not being improved sufficiently. Also in the second consent application, there would have been groundwater mounding causing some flooding on neighbouring properties. The mitigation proposed for the second site involved installing a well to extract groundwater to offset the extra water application during high groundwater periods.

It was at this juncture that CH2M Beca was invited by the Project Team for its input and we based a treatment upgrading suggestion on a ponds and wetlands treatment process which CH2M Beca had designed for plants at Oamaru, Moeraki and Blenheim. The CH2M Beca team also decided that the concept of pumping out groundwater, in order to mitigate treated wastewater application, had merit. However, we thought "*why not do this at the Leeston WWTP site*", given there is a psychological advantage in upgrading an existing situation, rather than involving a greenfields site.

The upgraded disposal concept would see treated wastewater continue to be discharged to the existing irrigation area, except when the groundwater was within 900mm of ground level. During wet periods, fully treated wastewater would be diverted through infiltration basins, located on the Leeston WWTP site, with the groundwater under the basins being pumped out from 12m deep wells.

All interested parties, including DoC and iwi, accepted the concept unanimously because of the passage through soil concept. Due to the very thorough consultative process, facilitated by a fully involved Project Team, there wasn't a need for a resource consent hearing.

What the Upgrading Involved

A crucial element in CH2M Beca's design concept was to substantially increase the size of the existing oxidation pond through raising the pond banks so that it would provide an additional 35,000m3 of wet weather storage. As well, a second 1.5ha primary oxidation pond was constructed with additional treatment also taking place in two new maturation ponds. Final "polishing" of the wastewater is carried out in 0.9ha of wetland ponds. These are divided into four cells, with the wastewater progressively filtered through porous gravel banks which separate each cell. In total, there are eight ponds-in-series.

Wastewater is then normally discharged through a network of new distribution pipes to the six border strip areas replacing the former open head races and gates, which leaked and gave uneven distribution of effluent. Bubble-up valves allow the operator to select and discharge wastewater more precisely.

During high rainfall periods when the groundwater table rises, the well-treated wastewater is diverted to six infiltration basins. Under the basins are six wells which pump out the groundwater from beneath the basins and into a local drain that flows into Lake Ellesmere. The geology of the area plays an important part in treating the wastewater, which filters down from the basins through a 12m deep substrata of sand and fine gravel.

Completed in nine months, the upgraded plant was opened in September 2003. Treatment performance is as expected and the annual nitrogen loading on the pasture is now below the allowable value. Excellent disinfection is being achieved by the eight ponds-in-series, without UV disinfection. The final effluent faecal coliform values are; median = 180, and 90 percentile = 620 (cfu/100 ml).

Other Communities to Benefit

Another key factor designed into Leeston's upgraded wastewater plant is its capacity for taking sewage not only from Leeston and Doyleston, but also the nearby townships of Southbridge and Dunsandel.

Southbridge has already been reticulated and connected to Leeston WWTP, receiving a MoH subsidy of $1.2 million towards the $3 million required for reticulation work, replacing septic tanks and soak holes which caused environmental and public health risks.

Thus, for Leeston's citizens and the Selwyn District Council, the upgraded Leeston WWTP has overcome concerns about the quality of treated wastewater being discharged into Lake Ellesmere and has improved public health protection in the nearby communities.

Boffa Miskell

Appendix D

Article on the Leeston Wastewater Treatment Plant Upgrade (from *Local Government Magazine – Asset Management*, Issue 5 No.2; February 2004)

LG NEW ZEALAND LOCAL GOVERNMENT MAGAZINE
Asset MANAGEMENT
FEBRUARY 2004 PROMOTING INFRASTRUCTURAL EXCELLENCE ISSUE 5 NO.2

Aerial view of the treatment ponds - the original oxidation pond has been more than doubled in size and primary oxidation and maturation ponds have been added.

Breakthrough disposal system

How the use of infiltration basins solved the wet weather overflow problems at the Leeston wastewater treatment plant.

Despite considerable improvements, the Leeston wastewater plant still left the Selwyn District Council faced with the problem of not being able to get a long term resource consent for treated discharge into nearby Lake Ellesmere. That is, until an innovative solution was proposed by CH2M Beca and backed by the council's commitment to a $2.2 million upgrade.

Humphrey Archer, CH2M Beca technical director of environmental engineering who, together with CH2M Beca senior civil engineer, David Gardiner, project engineered the upgrade, says the severity of the problem became apparent in 1992. "A rainstorm caused the wastewater treatment system to overflow flooding properties adjoining the plant with raw sewage."

Andrew Iremonger, Asset Manager Water for the Selwyn District Council, describes the treatment plant's poor effluent quality and ▷

◁ *From previous page*

discharge to a local water way as an ongoing worry. "In our dry summers treated wastewater is discharged to land through border strip irrigation, but come winter our district has very high groundwater levels - 900mm from the surface - which discounts using that method.

"With our consent to discharge to the drain having almost expired, the council was faced with finding an alternative method because it was highly unlikely that the consent would be renewed."

Nor was it the only problem associated with Leeston's sewage system, as Mr Iremonger explains. "High ground water levels in winter results in very high infiltration into the sewer reticulation. The major cause is with old earthenware pipes between property boundaries and the houses is causing an ongoing problem

But knowing the problem was one thing, finding an acceptable answer proved a lot less easy.

"The consent process was long and tortuous, spanning 10 years," Mr Iremonger wryly recalls. To ensure the interests of both Leeston and its neighbour Doyleston, which is connected to the plant, were well considered, the Leeston/Doyleston Sewerage Project Team was formed.

It comprised members of the community, ward councillors along with council-appointed consultants who focused on finding a better alternative for wastewater treatment and disposal that would also take into account future expansion in both townships over the next 20 years.

That first flush of success: Selwyn District Mayor Michael McEvedy performs the official first flush watched by Township Committee chairperson Lloyd Clausen.

Proposed wastewater disposal alternatives such as coastal discharge or linking up with the Lincoln or Christchurch sewage systems were dismissed due to environmental, cultural or cost considerations.

Two proposals, however, held promise. These involved pumping peak flows from the oxidation pond to remote sites that were more elevated and had better drainage.

But both proposals failed their consent applications. "This was because the treatment standard wasn't being improved sufficiently in the first consent application so the problem was merely being shifted to a remote site," says Mr Iremonger. "Moreover on the second consent application there would have groundwater mounding perceived by property owners to cause some flooding on a neighbouring property."

The mitigation proposed for the second site involved installing a well to suck out the groundwater to offset the extra water flowing into it during high groundwater periods.

It was at this juncture that CH2M Beca was invited by the project team for its input. "We based our upgrading suggestions on a ponds and wetlands treatment process which we'd already designed for plants at Oamaru and Moeraki," says Mr Archer.

The CH2M Beca team also decided the concept of pumping out groundwater in order to accommodate treated wastewater had merit - "but we thought, why not do this at the Leeston site. There's a psychological benefit of upgrading at the source rather than at a green fields site," says Mr Archer.

The disposal system would see wastewater continue to be discharged to the existing irrigation area except when the groundwater level exceeded that 900mm below ground level.

During these wet periods wastewater disposal would be diverted through infiltration basins, located adjacent to the sewage treatment plant, with the groundwater under the basins being pumped out from 12m deep wells.

"All interested parties, including DoC and iwi, accepted the concept unanimously because of the passage through soil concept," says Mr Archer, a response he also attributes to the very thorough consultative process. "There wasn't even the need for a resource consent hearing."

However, the upgrade has involved infinitely more than installing a new disposal method. "The quality of our treated wastewater should vastly improve through the addition of such things as a new oxidation pond, maturation ponds and wetlands," explains Mr Iremonger.

WHAT THE UPGRADE INVOLVED

A crucial element in CH2M Beca's design conception was to increase the size of the existing oxidation pond - two-and-half fold - through raising the pond banks so that it now provides an additional 35,000 m3 of wet weather storage.

As well, a second 1.5ha primary oxidation pond has been constructed with additional treatment now taking place in two new maturation ponds.

Each pond has a 300mm thick silt liner and is contained within - and protected by - 250mm thick rock rip rap batters.

The primary and maturation ponds remove enteric bacteria and viruses from the wastewater mainly by sunlight disinfection.

A final "polishing" of the wastewater is carried out in .9ha of wetlands. These are divided into four cells with the wastewater progressively filtered through porous gravel ▷

AM CONTENTS Pages 9-23

Bubble-up valves provide more precise discharging of treated wastewater for border strip irrigation.

banks which separate each cell.

Mother Nature also plays a hand in making this "polishing" process particularly effective - "the gravel filters together with the wetlands plants should further reduce levels of ammonia and nitrogen by at least 50 per cent, and the soils absorb phosphates," notes Mr Iremonger.

Wastewater is then normally discharged through a network of new distribution pipes to the six border strip areas replacing the former headraces and gates which leaked and gave uneven distribution of effluent.

Bubble-up valves allow the operator to select and discharge wastewater more precisely. "That's an important consideration," explains Mr Archer, "given how dry this area can get over the summer."

But when the rains fall and the groundwater table rises, the wastewater is diverted to six infiltration basins immediately to the west of the maturation ponds and wetlands. "This was arguably the most critical part of the upgrade," says Mr Iremonger.

"The infiltration basins swung the community in favour of the upgrade," asserts Mr Iremonger, "because a resource consent was achievable."

Under the basins are six wells which, when the wastewater is to be diverted into the basins due to high groundwater levels, pump out the groundwater from beneath the basins and into a local drain followed by discharge into Lake Ellesmere.

Again, the geology of the area plays an important part in treating the wastewater: it filters down from the basins through a 12m deep substrata of sand and fine gravel.

Completed in nine months, the upgraded plant was opened in September 2003.

FOUR COMMUNITIES TO BENEFIT

Another vital factor designed into Leeston's upgraded wastewater plant is its capacity for taking sewage from two adjoining townships.

At present only wastewater from Leeston and Doyleston is conveyed to the plant. However, the upgrade took into account the intention to ultimately treat sewage from nearby townships of Southbridge and Dunsandel.

In fact, the consent applications for the Leeston upgrade were secured on the understanding that both Southbridge and Dunsandel could be included in the future.

For Southbridge the future is fast approaching. The feasibility of the township being connected to the plant saw the Ministry of Health, under its subsidy scheme, provide $1.2 million towards the $3 million required for reticulation work.

The inducement for this government largesse is that both Southbridge and Dunsandel households are on septic tanks which result in considerable environmental problems.

Mr Iremonger notes the necessity of this subsidy. He explains that without it, each property can face a very heavy levy. In the case of Southbridge property owners it would have been $9000 (includes reticulation within Southbridge) and Leeston the cost per property was $3818.

The Selwyn District Council is now weighing up when and how Dunsandel can also be connected to the plant.

The fact that this township is 14km from the wastewater treatment plant creates no problems says Mr Archer. "Welded polyethylene pipes give reliable, no-leak performance over considerable distances."

Meanwhile for Leeston's citizens and the council, the upgraded wastewater treatment plant means there is no longer a concern about the quality of treated wastewater being discharged into Lake Ellesmere. ■

Appendix E

Selected Chemical Characteristics of Soils, Forages, and Drainage Water from the Sewage Farm Serving Melbourne Australia, Department of the Army (USA), Corps of Engineers, January 1974

SELECTED CHEMICAL CHARACTERISTICS OF SOILS, FORAGES, AND DRAINAGE WATER FROM THE SEWAGE FARM SERVING MELBOURNE, AUSTRALIA

Contributing Authors

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January 1974

Prepared for

DEPARTMENT OF THE ARMY

Corps of Engineers

BACKGROUND

The Board of Works Farm at Werribee was established in 1897, and currently receives raw sewage generated by the 2.5 million people of metropolitan Melbourne, Australia. Contributions to the sewage flow include domestic wastes, industrial wastes, urban storm runoff, and ground water infiltration. The daily amounts of sewage arriving at the Farm vary greatly depending upon rainfall. The current average flow is about 546,000m^3/day (144 MGD), however, peak flows as high as 1,140,000m^3/day (300 MGD) during storm periods occur.

Rainfall at the Farm averages 48.3 cm (19 in.) annually of which about 32.2 cm (12.5 in.) of evenly distributed rainfall can be expected during the irrigation season, whereas, the evapotranspirational potential during the same period averages about 90.4 cm (35.6 in.), suggesting that a major portion of the annual application of 112 cm (44 in.) of sewage water is evaporated.

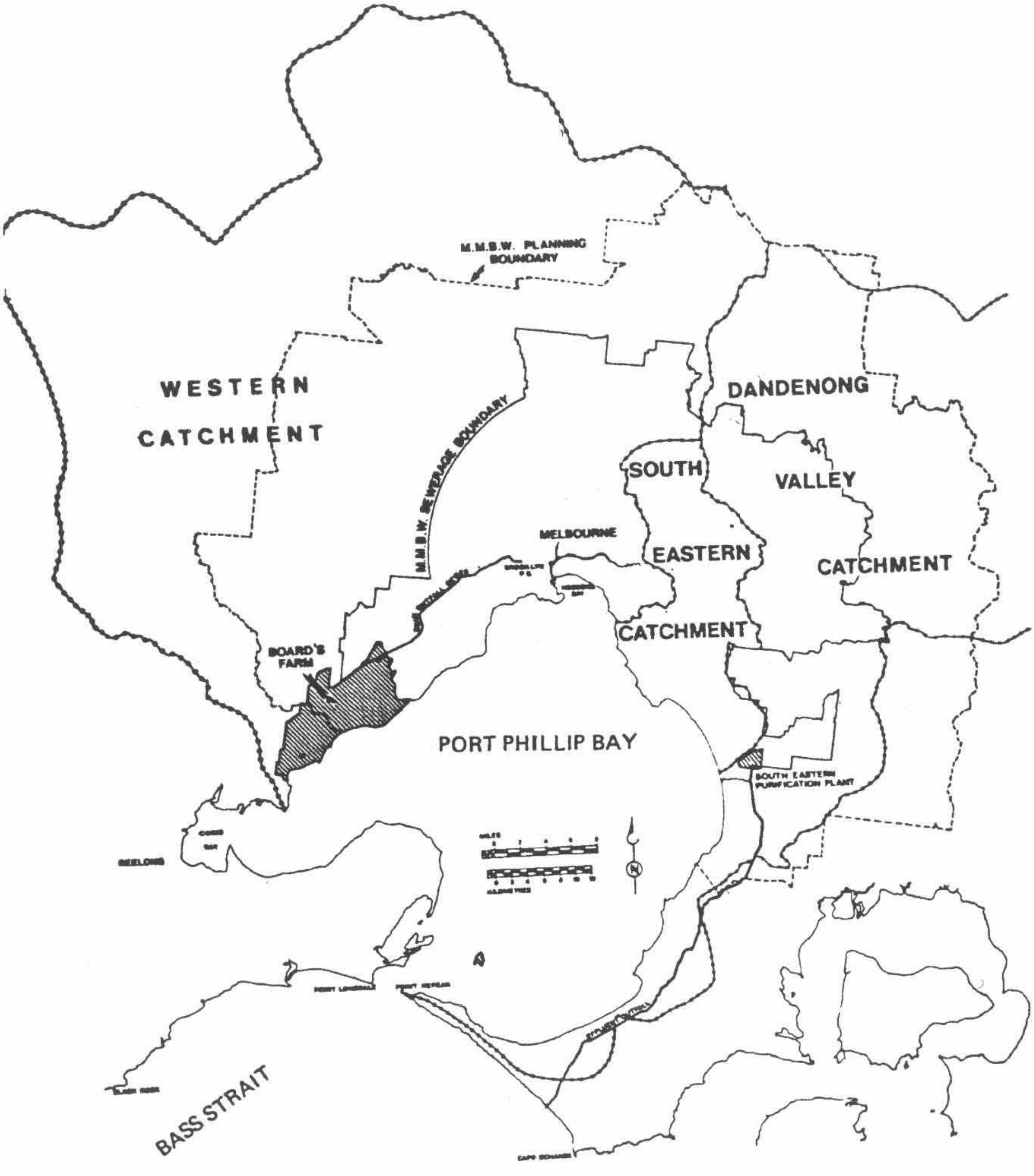
The Board of Works system utilizes three different treatment processes at various times of the year. Land filtration (irrigated permanent pasture), the principal treatment method used throughout the six to seven month summer season, encompasses 4,200 ha (10,376 A) of the total farm and treats about 273,000m^3/day(72 MGD). This process, which is a flood irrigation system using check borders, allows wastewater to percolate through the soil and subsequently to be collected in deep, open drains or ditches. In 1897 the land filtration area was divided into 8.1 ha (20 A) paddocks consisting of many individual bays which are still being used today. Each bay is 0.16 ha (0.4 A) in extent and surrounded by low check banks to permit a 10 cm (4 in.) application of water without run-off. Initially these bays were deep-plowed to a depth of 76 cm (30 in.) to break up the less permeable subsoil. The irrigation paddocks are sown with a mixture of grasses and legumes to provide balanced pasture production throughout the year. Some of the sewage arriving at the Farm goes through a primary treatment process of sedimentation providing several hours of detention. However, part of the older land-filtration area of the Farm is irrigated with raw sewage without prior sedimentation. Sewage is applied every 18 to 20 days with each block covered to a depth of about 10 cm (4 in.). In all, approximately 243 ha (600 A) are irrigated each day.

The other two treatment methods consist of "grass filtration" (overland flow) which is used in the winter time in lieu of land filtration, and oxidation ponds to handle the balance of the normal flow and wet weather excess. The processes occupy 1405 ha (3472 A) and 1375 ha (3393 A), respectively, while 2,830 ha (7000 A) of the Farm are reserved for dry grazing of livestock. Since these two processes were not specifically the subject of this investigation, they will not be discussed further.

Soil and Forage Characteristics

Much of the Board of Works Farm is situated on soils derived from either Pleistocene basalt or Pleistocene riverine sediments, which are somewhat variable. The investigations presented in this report are confined to the older part of the Farm which is almost entirely Pleistocene alluvium of the Werribee Series (See Figure 1). These sediments are derived from weathering products of Pleistocene basalt.

Although no detailed classification or mapping has been carried out for the Farm soils, Skene (27) has completed a survey of irrigated soils at the Farm. Typically, the surface of the soil profile consists of a red-brown silty clay loam which is slightly acid. Calcareous silty clay occurs at a depth of about 30 cm where the exchange complex of the clay becomes increasingly dominated by exchangeable Mg and Na with depth. From particle size distribution analyses of six core samples it was found that the soils averaged about 35 percent clay, 45 percent silt, and 20 percent sand. The upper 30.5 to 91.5 cm of the soil showed liquid limits ranging from 32 to 41 (average about 37) and plastic limits ranging from 13 to 22. While the profile is only slowly permeable, the soil can take about 2 cm of water a day. A mixture of grasses includes perennial rye (*Lolium pratense*), Italian rye (L. *multiflorum*), white clover (*Trifolium repens*), strawberry clover (*T. fragiferum*), alsike clover (*T. hybridum*), cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*), and meadow fescue (*Festuca elatior*). Perennial rye grass dominates most of the irrigated land, but in successively wetter spots there is marine barley grass (*Hordeum marinum*) and docks, with water couch (*Agropyron repens*) in the wettest spots. Under irrigation and with grazing a 2- to 5-cm thick layer of loam rich in organic matter has developed on the surface (20).*



MELBOURNE AND METROPOLITAN AREA

Appendix F

Aerial photographs of Oxidation Ponds and Border Strip Irrigation Areas at the Melbourne Western Wastewater Treatment Plant at Werribee, Victoria (from Google Earth)

Melbourne Western WWTP at Werribee

Note: Dark areas are the oxidation ponds and green areas are border strip irrigation. Total area is 11,000 hectares.

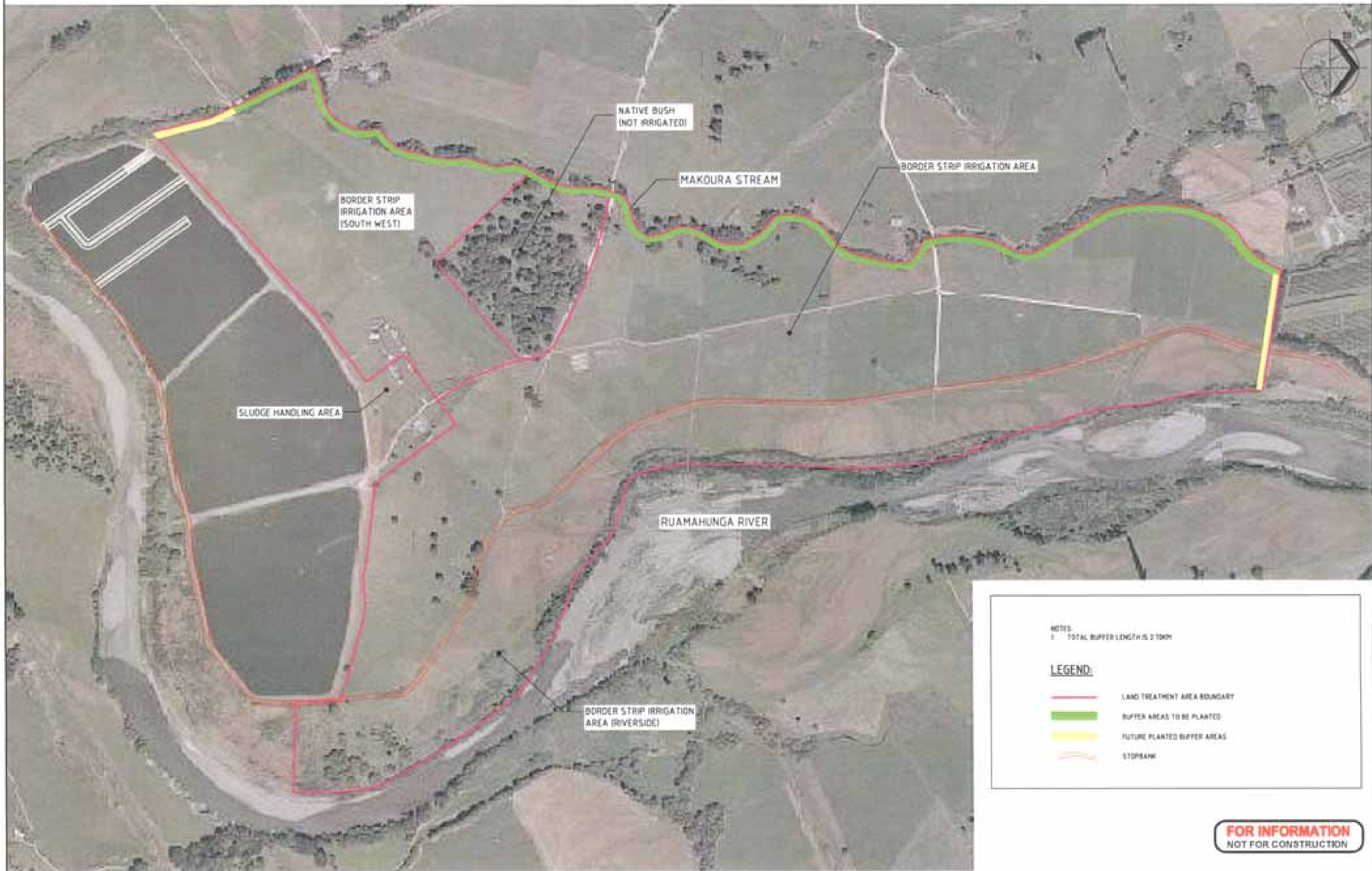
Melbourne Western WWTP at Werribee

Note: Dark areas are the oxidation ponds and green areas are border strip irrigation.
Total area is 11,000 hectares.

Boffa Miskell

Appendix G

Updated Figure 20 from AEE, showing Buffer Planting Layout for Border Dyke Irrigation Area (Beca Plan 3202216/ SK02 Rev B)



FOR INFORMATION
NOT FOR CONSTRUCTION

No	Revision	By	Date
C	CHANGE BORDER STRIP	MBC	
B	FOR INFORMATION	KAS	

Beca Engineers • Planners • Managers

Masterton District Council — Serving the Community

MASTERTON WWTP
LAND TREATMENT AREA

BUFFER PLANTING
LAYOUT

CIVIL

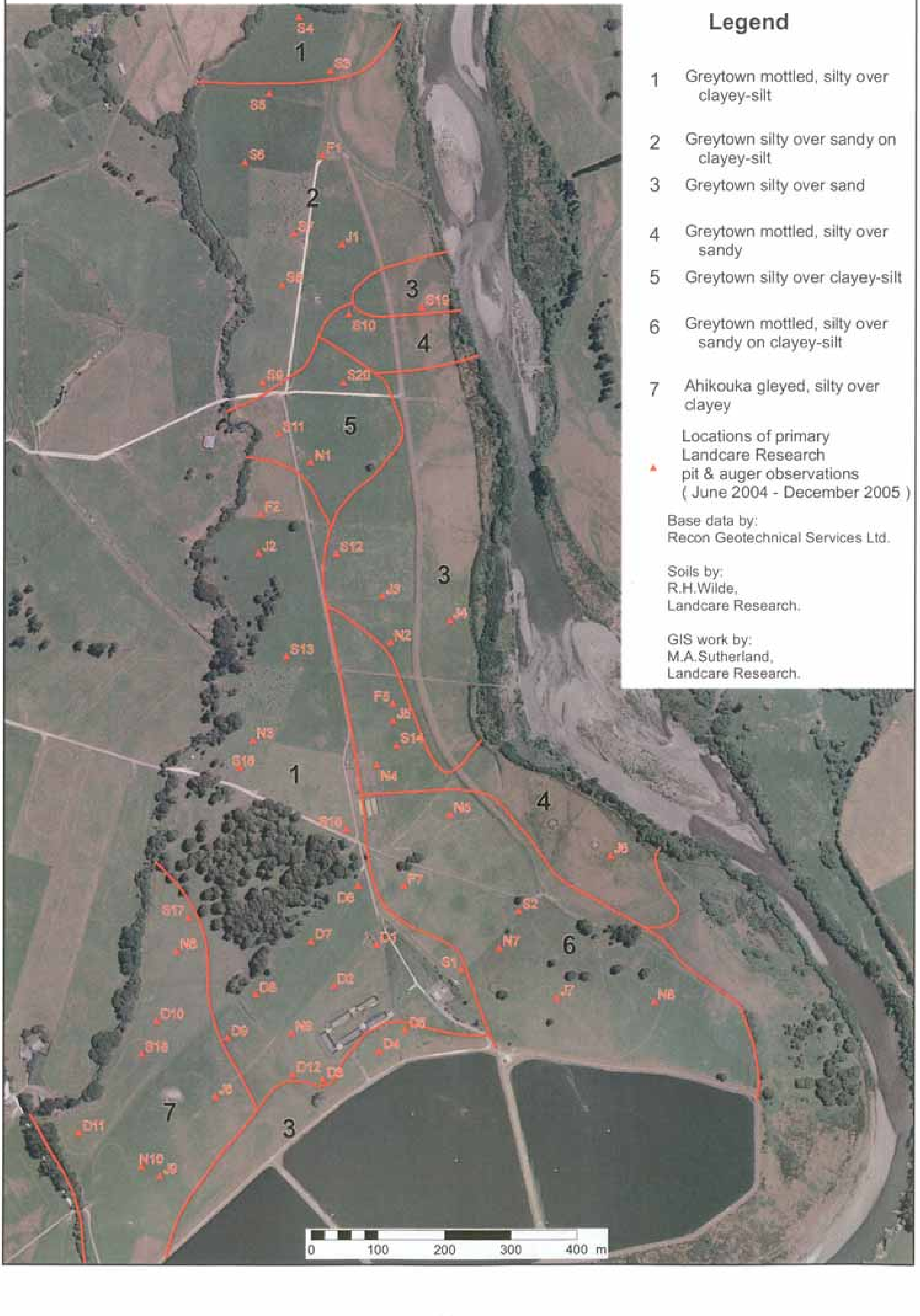
3202216/SK02 C

Boffa Miskell

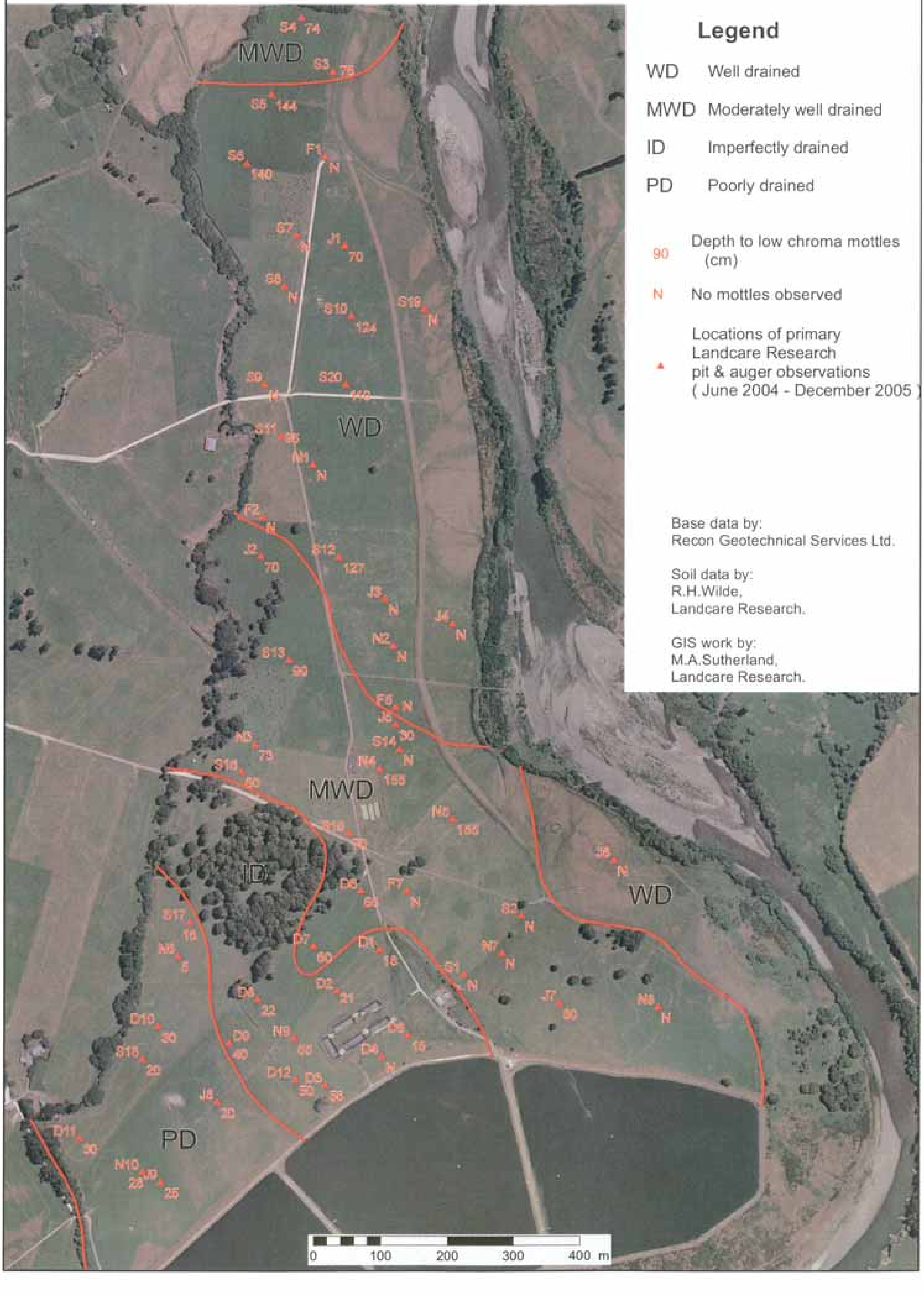
Appendix H

Soil Maps and Test Borehole Sites, Proposed Border Dyke Irrigation Area (from Landcare Research 2005)

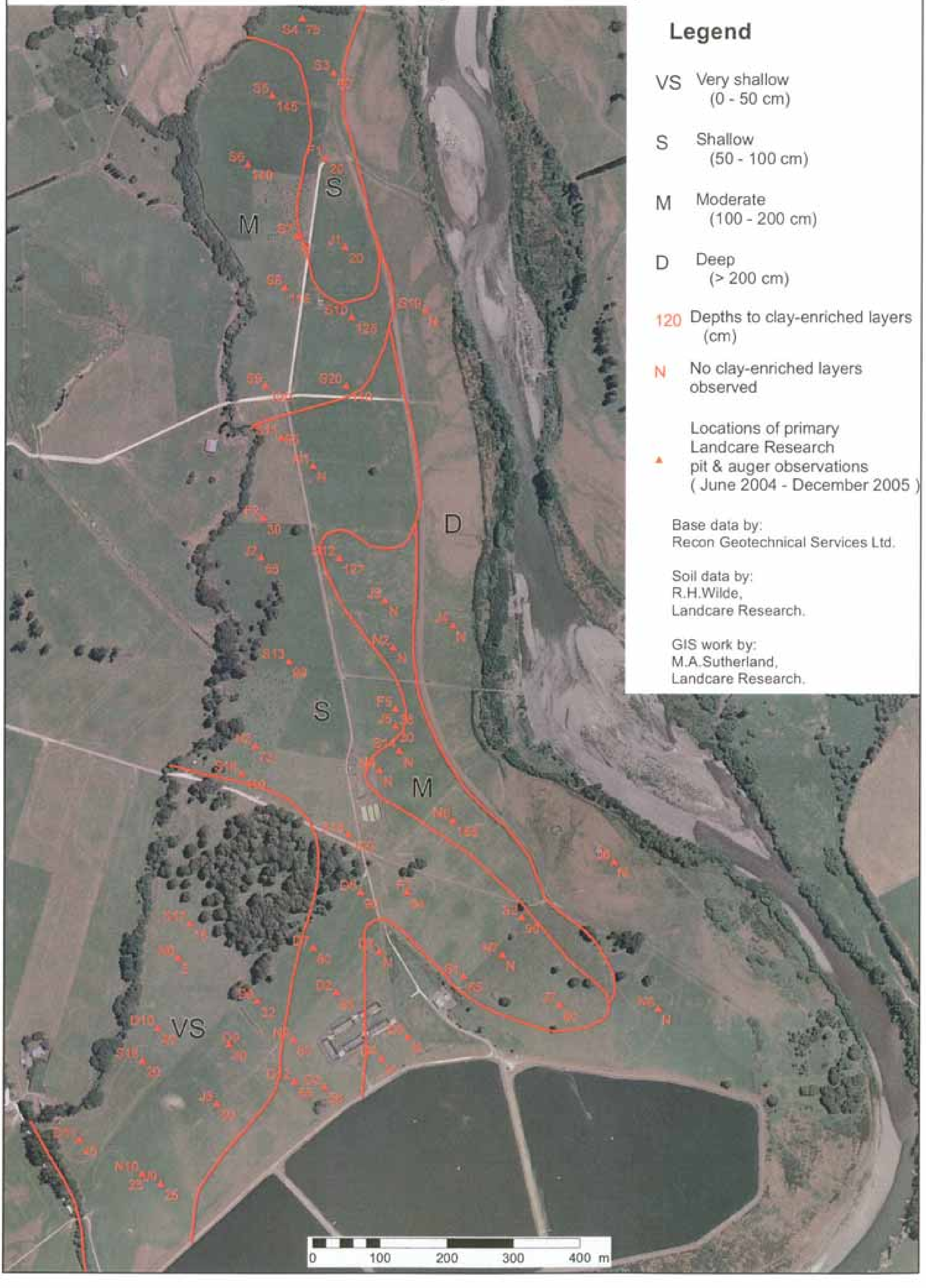
Appendix 1a: Proposed Homebush Effluent Disposal Site Soils



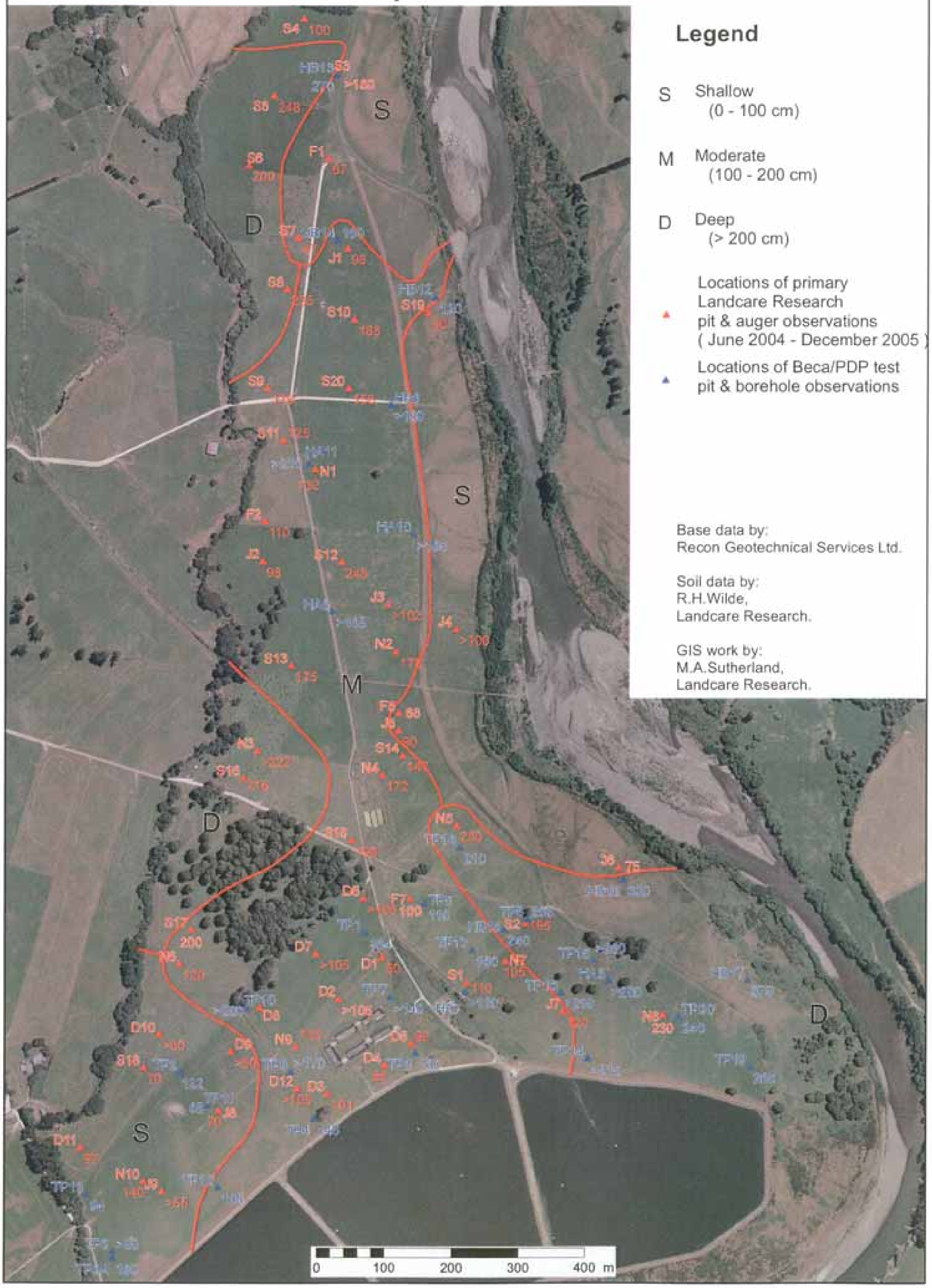
Appendix 1b: Proposed Homebush Effluent Disposal Site Soil Drainage Classes



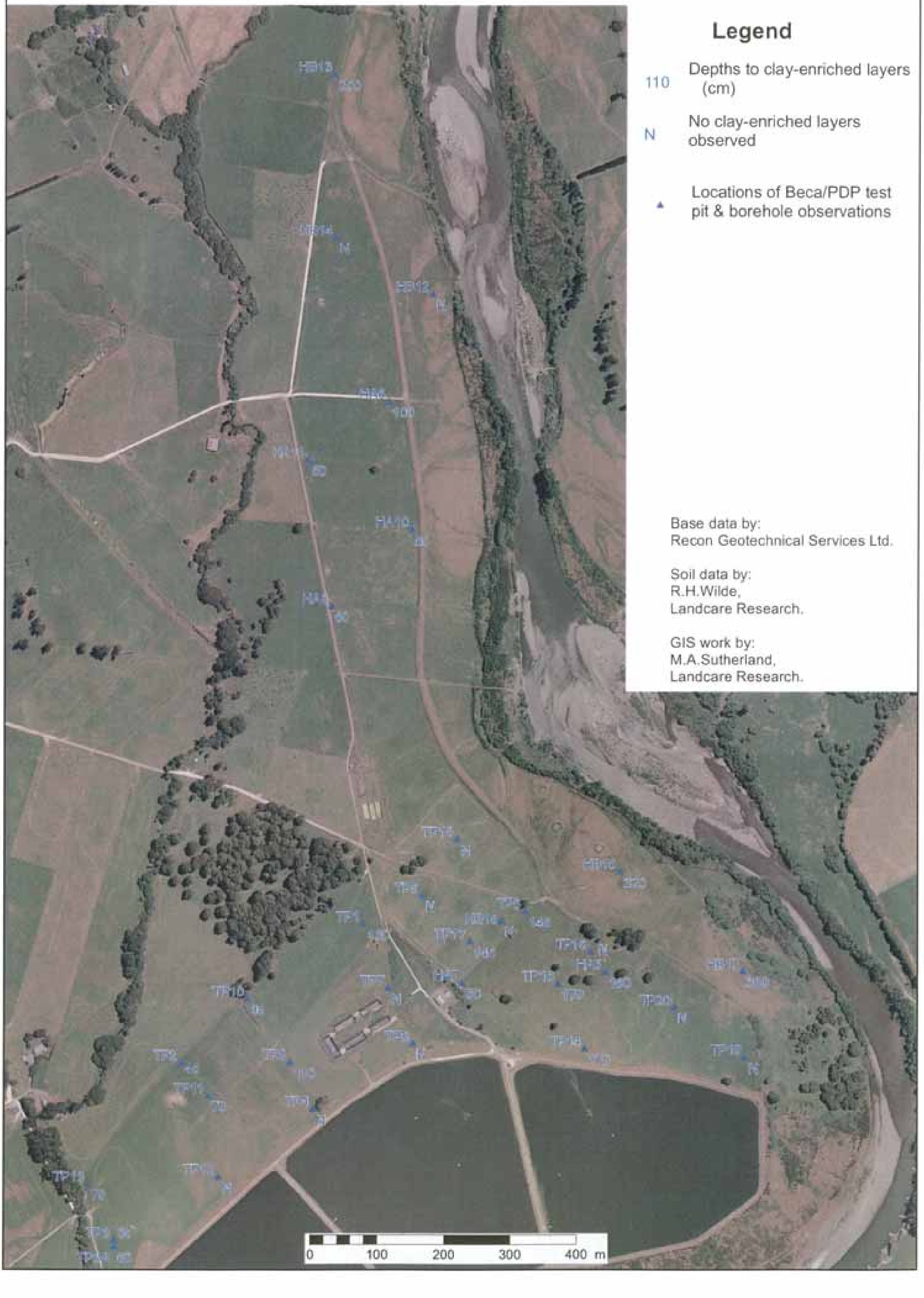
Appendix 1c: Proposed Homebush Effluent Disposal Site Depth to Clay-enriched Layers



Appendix 1d: Proposed Homebush Effluent Disposal Site Depths to Gravels



Appendix 1e: **Proposed Homebush Effluent Disposal Site**
Beca & PDP Test Pits and Boreholes



Appendix I

Plan Showing Proposed Groundwater Monitoring Bores

Scale: 1:10,000 at A4

N

Masterton Effluent Irrigation

Proposed Groundwater Monitoring Bores

Legend:

● Approximate Borehole Loactions

Beca

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